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ABSTRACT

This fourth interim report in a series prepared for the Congress concerns the impact of increasing worldwide use of the metric system on the manufacturing industries of the United States. It presents the results of a study based on responses to a questionnaire survey from more than 2,000 manufacturing companies. Detailed findings include current and anticipated use of the metric system and manufacturers' views on metrication. An intensive study of estimated metrication costs was made by a smaller sample of selected companies. Related materials are available as VT 018 023-018 028 and VT 018 036-018 037 in this issue, and VT 017 558 and VT 017 564 in March 1973 RIE. (MF)

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U.S. METRIC STUDY
INTERIM REPORT

ED 070831

THE MANUFACTURING INDUSTRY

U.S. METRIC STUDY

U.S.
DEPARTMENT
OF
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NBS SP 345-4

U.S. METRIC SUBSTUDY REPORTS

The results of substudies of the U.S. Metric Study, while being evaluated for the preparation of a comprehensive report to the Congress, are being published in the interim as a series of NBS Special Publications. The titles of the individual reports are listed below.

REPORTS ON SUBSTUDIES

NBS SP345-1: International Standards (issued December 1970, SD Catalog No. C13.10:345-1, Price $1.25)
NBS SP345-2: Federal Government: Civilian Agencies (in press)
NBS SP345-3: Commercial Weights and Measures (in press)
NBS SP345-4: The Manufacturing Industry (this publication)
NBS SP345-5: Nonmanufacturing Businesses (in press)
NBS SP345-6: Education (in press)
NBS SP345-7: The Consumer (in press)
NBS SP345-8: International Trade (in press)
NBS SP345-9: Department of Defense (in press)
NBS SP345-10: A History of the Metric System Controversy in the United States (in press)
NBS SP345-11: Engineering Standards (in press)
NBS SP345-12: Testimony of Nationally Representative Groups (in press)

COMPREHENSIVE REPORT ON THE U.S. METRIC STUDY

NBS SP345: To be published in August 1971

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U.S. METRIC STUDY INTERIM REPORT

THE MANUFACTURING INDUSTRY

**Fourth in a series of reports prepared
for the Congress**

**U.S. METRIC STUDY
Daniel V. De Simone, Director**

National Bureau of Standards
Special Publication 345-4

UNITED STATES DEPARTMENT OF COMMERCE
Maurice H. Stans, *Secretary*
NATIONAL BUREAU OF STANDARDS
Lewis M. Branscomb, *Director*

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LETTER OF TRANSMITTAL

THE HONORABLE PRESIDENT OF THE SENATE
THE HONORABLE SPEAKER OF THE HOUSE OF REPRESENTATIVES

SIRS:

I have the honor to present the fourth in the series of interim reports stemming from the U.S. Metric Study, prepared by the National Bureau of Standards.

This Study was authorized by Public Law 90-472 to reduce the many uncertainties concerning the metric issue and to provide a better basis upon which the Congress may evaluate and resolve it.

I shall make a final report to the Congress on this Study in August 1971. In the meantime, the data and opinions contained in this interim report are being evaluated by the Study team at the National Bureau of Standards. My final report to you will reflect this evaluation.

Respectfully submitted,

Maurice H. Stans

Secretary of Commerce

Enclosure

LETTER OF TRANSMITTAL

Honorable Maurice H. Stans
Secretary of Commerce

Dear Mr. Secretary:

I have the honor to transmit to you another interim report of the U.S. Metric Study, which is being conducted at the National Bureau of Standards at your request and in accordance with the Metric Study Act of 1968.

The Study is exploring the subjects assigned to it with great care. We have tried to reach every relevant sector of the society to elicit their views on the metric issue and their estimates of the costs and benefits called for in the Metric Study Act. Moreover, all of these sectors were given an opportunity to testify in the extensive series of Metric Study Conferences that were held last year.

On the basis of all that we have been able to learn from these conferences, as well as the numerous surveys and investigations, a final report will be made to you before August 1971 for your evaluation and decision as to any recommendations that you may wish to make to the Congress.

The attached interim report includes data and other opinions that are still being evaluated by us to determine their relationship and significance to all of the other information that has been elicited by the Study. All of these evaluations will be reflected in the final report.

Sincerely,

Lewis M. Branscomb

Lewis M. Branscomb, *Director*
National Bureau of Standards

Enclosure

FOREWORD

This report concerns the implications of increasing worldwide use of the metric system on the manufacturing industry of the United States. It is based upon a questionnaire survey of the industry, which was asked for its views on the basic issues set forth in the Metric Study Act (Public Law 90–472). Because of the importance of measurement-related practices and standards to the manufacturing industry, it is vitally concerned with any possible changes in the U.S. measurement system.

Reports covering other substudies of the U.S. Metric Study are listed on the inside front cover. All of these, including this report, are under evaluation. Hence, they are published without prejudice to the comprehensive report on the entire U.S. Metric Study, which will be sent to the Congress by the Secretary of Commerce in August of 1971.

This report was prepared by Westat Research, Inc., under the direction of Morris H. Hansen, former Associate Director of the United States Bureau of the Census, and an internationally recognized authority on the conduct of statistical surveys. The principal staff members of the National Bureau of Standards who developed the questionnaires used in the survey of the manufacturing industry and who assisted Westat in the preparation of this report were Louis E. Barbrow, Manager of the Manufacturing Survey, and Alvin G. McNish, a senior consultant to the U.S. Metric Study.

Mr. McNish, who played the major role in enlisting the cooperation of companies willing to conduct cost studies, prepared the "Critique on Metrication Cost Estimates in Manufacturing", which prefaces the report by Westat Research, Inc.

Other members of the manufacturing survey staff under Mr. Barbrow's direction were George C. Lovell, Robert R. Rohrs, Mrs. Carolyn L. Flood, Mrs. Alice B. Margeson, and Mrs. Judy M. Melvin.

We are grateful to all of the companies that participated in the survey of the manufacturing industry. Over 2,000 companies provided the information upon which this report is based. Of these, over 100 companies went to the considerable additional expense of supplying information on the added cost that increased metric use would entail in the manufacture of their products. Special thanks go also to the American National Standards Institute, which provided invaluable assistance in the development of fundamental guidelines for the Manufacturing Survey.

In this as in all aspects of the U.S. Metric Study, the program has benefited from the independent judgment and thoughtful counsel of its advisory panel and the many other organizations, groups, and committees that have participated in the Study.

Daniel V. De Simone, *Director*
U.S. Metric Study

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*App. E, which consists of printouts of the detailed data on which this report is based, has not been printed but a limited number of copies have been reproduced and are available at $6.00 each from the National Technical Information Service, Springfield, Va. 22151. Copies may be ordered under NTIS No. COM-71-00517.

Public Law 90-472 # An Act 82 STAT. 693

To authorize the Secretary of Commerce to make a study to determine the advantages and disadvantages of increased use of the metric system in the United States.

Metric system.
Study.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of Commerce is hereby authorized to conduct a program of investigation, research, and survey to determine the impact of increasing worldwide use of the metric system on the United States; to appraise the desirability and practicability of increasing the use of metric weights and measures in the United States; to study the feasibility of retaining and promoting by international use of dimensional and other engineering standards based on the customary measurement units of the United States; and to evaluate the costs and benefits of alternative courses of action which may be feasible for the United States.

Investigation and appraisal requirements.

SEC. 2. In carrying out the program described in the first section of this Act, the Secretary, among other things, shall—

(1) investigate and appraise the advantages and disadvantages to the United States in international trade and commerce, and in military and other areas of international relations, of the increased use of an internationally standardized system of weights and measures;

(2) appraise economic and military advantages and disadvantages of the increased use of the metric system in the United States or of the increased use of such system in specific fields and the impact of such increased use upon those affected;

(3) conduct extensive comparative studies of the systems of weights and measures used in educational, engineering, manufacturing, commercial, public, and scientific areas, and the relative advantages and disadvantages, and degree of standardization of each in its respective field;

(4) investigate and appraise the possible practical difficulties which might be encountered in accomplishing the increased use of the metric system of weights and measures generally or in specific fields or areas in the United States;

(5) permit appropriate participation by representatives of United States industry, science, engineering, and labor, and their associations, in the planning and conduct of the program authorized by the first section of this Act, and in the evaluation of the information secured under such program; and

(6) consult and cooperate with other government agencies, Federal, State, and local, and, to the extent practicable, with foreign governments and international organizations.

Results of changes in measurement system.

SEC. 3. In conducting the studies and developing the recommendations required in this Act, the Secretary shall give full consideration to the advantages, disadvantages, and problems associated with possible changes in either the system of measurement units or the related dimensional and engineering standards currently used in the United States, and specifically shall—

(1) investigate the extent to which substantial changes in the size, shape, and design of important industrial products would be necessary to realize the benefits which might result from general use of metric units of measurement in the United States;

(2) investigate the extent to which uniform and accepted engineering standards based on the metric system of measurement units are in use in each of the fields under study and compare the extent to such use and the utility and degree of sophistication of such metric standards with those in use in the United States; and

(3) recommend specific means of meeting the practical difficulties and costs in those areas of the economy where any recommended change in the system of measurement units and related dimensional and engineering standards would raise significant practical difficulties or entail significant costs of conversion.

Report to Congress.

SEC. 4. The Secretary shall submit to the Congress such interim reports as he deems desirable, and within three years after the date of the enactment of this Act, a full and complete report of the findings made under the program authorized by this Act, together with such recommendations as he considers to be appropriate and in the best interests of the United States.

Funds.

SEC. 5. From funds previously appropriated to the Department of Commerce, the Secretary is authorized to utilize such appropriated sums as are necessary, but not to exceed $500,000, to carry out the purposes of this Act for the first year of the program.

Expiration date.

SEC. 6. This Act shall expire thirty days after the submission of the final report pursuant to section 3.

Approved August 9, 1968.

PREFACE

CRITIQUE ON METRICATION COST ESTIMATES IN MANUFACTURING

by A. G. McNish

The returns from the cost questionnaire present a phantasmagoria to anyone who would attempt to analyze the results. The estimated costs of metrication range over a factor of 900 for industries engaged in the manufacture of mechanical products. This excludes, of course, those industries, such as the pharmaceutical industry, where metrication has already been accomplished and where the costs were estimated at less than 0.05 of one percent. The returns do not seem amenable to any simple statistical treatment since the companies sampled were not selected on a random basis. It seemed clear at the outset that reliable estimates of cost could be obtained only from companies willing to devote the necessary effort and considerable expense involved in estimating these costs. Such a selection of companies, it seemed, could not be obtained on a random sampling basis since a willingness to participate implied a more than normal interest. (A *post facto* attempt by Westat to achieve such cooperation from companies on a random basis demonstrated the soundness of this preliminary conclusion; see p. 90.)

The companies solicited to conduct studies included many that had in the past expressed opposition to any change in the measurement system. Many of these companies had had experience in dealing with the problems involved in a dual dimensional system. Some of them had in the past been involved in the problem of metrication because of their international relations. It was thought that such companies could give more reliable estimates than those with little or no experience in this area, where judgments might be based upon hearsay and past prejudices.

The Act under which the study was conducted particularly called for a recommendation regarding "specific means of meeting the practical difficulties and costs in those areas of the economy where any recommended change in the system of measurement units and related dimensional and engineering standards could raise significant practical problems or entail significant cost of conversion." For this reason, companies selected to make the study included principally those companies shown by preliminary studies to be in areas of most significant economic impact. Although a strong effort was made to see that participants were adequately prepared for the task, it seems that many of the reports came from companies without adequate background preparation. Nevertheless, the reports from these companies are included in the analysis of the final returns and an attempt is made to evaluate them in the perspective set forth.

Preliminary studies indicated that the problems involved in some industries might be completely different from those in others. Even within a single 4-digit industrial classification problems might be quite antithetical (see p. 10). It was necessary to proceed on the assumption that some commonality of problems existed within each industrial classification. The most serious problems seemed to be associated with the mechanical products industries, particularly industries in the 3500 category involving machinery other than electrical. For this reason more companies were solicited in the 3500 category as respondents to the questionnaire, and as anticipated the estimated costs in this major group were the largest of any of the groups sampled, except for the 3400 group which is strongly affected by the six responses of the fastener industry.

How realistic are these estimates of the cost of metrication? There is no doubt that the estimates represent in most cases very sincere assessments of cost on the part of the respondent. Yet, that the estimates will indeed be the costs which would be encountered by the various companies concerned, were they to actually engage in metrication, is somewhat in doubt. Many companies devoted much greater effort to the study than others. In a few cases it has been possible to follow up on the responses of the various respondents and to ascertain, to some extent, what caused differences in their estimates. These will be treated on an anecdotal basis presented later.

For the purpose of analysis, industries were grouped as follows:

Major groups 2000 to 3200 including food, tobacco, textile, apparel, lumber, furniture, paper, printing, chemical, plastic, leather and ceramic industries were grouped together because these have some commonality of problems. Treated separately were primary metals industries, fabricated metals industries, nonelectrical machinery, electrical machinery, transportation equipment, and instruments. Too few reports were obtained from companies in the 1900 industry group, ordnance, and the 3900 industry group, other manufactured products, to treat these groups separately. Problems in the ordnance industry are very similar to those in the nonelectrical machinery industries and ordnance may be grouped with them. Problems arising in the 3900 industries including toys, jewelry, etc. are probably very slight as far as metrication is concerned.

Cost estimates taken from the questionnaires are plotted in figures A to D where the cost of metrication in terms of percentage of value added by manufacture is shown on a logarithmic scale because of the wide range in estimates. The abscissae in these figures are the SIC industry numbers.

In the 2000 to 3200 industry groups (fig. A) the estimates cover a 35-fold range with half the estimates falling under 3 percent. Three companies engaged in pharmaceuticals reported estimates of zero to 0.05 percent. In the food industry estimates cover a 13-fold range. The highest estimate in these industries came from a paper manufacturer who estimated 29 percent.

Estimates from companies engaged in primary metals (fig. B) cover a 73-fold range. Particular attention is called to a nonferrous metal company which reported 41.7 percent.

Estimates from companies engaged in fabricated metals other than machinery, cover a 44-fold range, all of this range being exhibited by industry 3411, metal cans. This major group includes the fastener manufacturers, industry 3452.

Figure A

Total Cost of Metrication as Percentage of Value Added by Manufacture in 1969

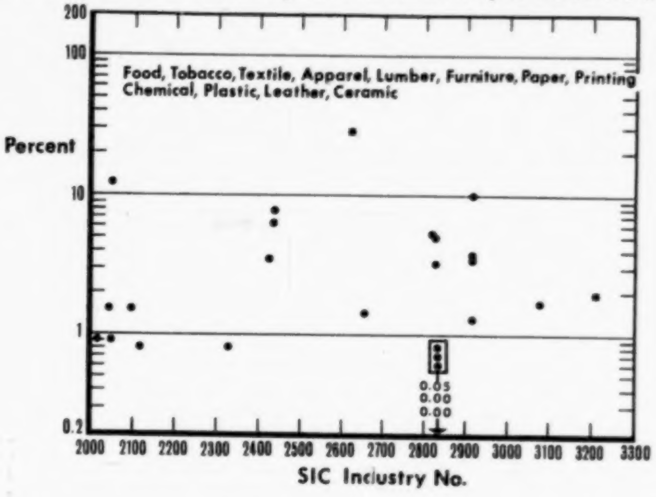
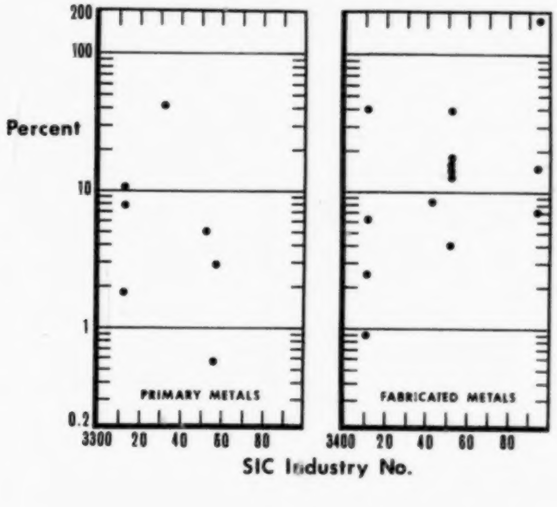


Figure B

Total Cost of Metrication as Percentage of Value Added by Manufacture in 1969

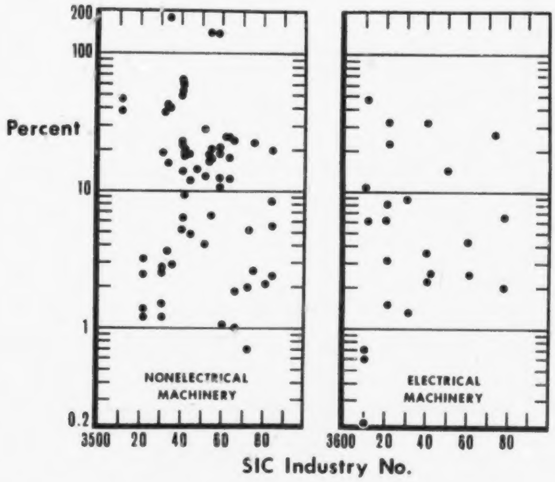


Nonelectrical machinery companies (fig. C) reported estimates ranging by a factor of 260. Responses were solicited from more companies in this major industry group than any other and in a number of cases include several companies engaged in manufacture of the same product.

Companies manufacturing electrical machinery and equipment cover a 230-fold range.

Figure C

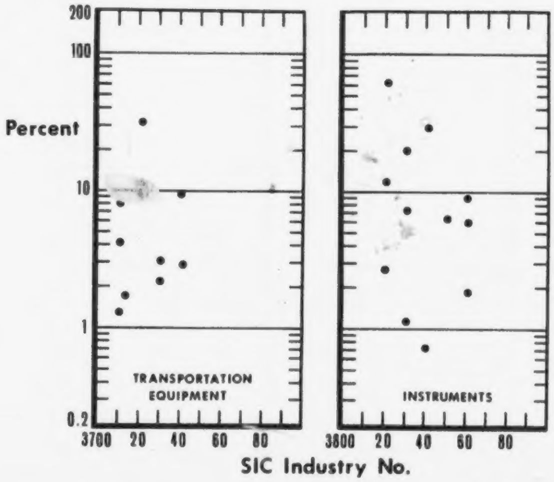
Total Cost of Metrication as Percentage of Value Added by Manufacture in 1969



Transportation equipment manufacturers (fig. D) range over a factor of 23 in their estimates, the higher estimates coming from the aircraft industry. Estimates from the companies engaged in the manufacture of scientific and controlling instruments differ in their estimates by a factor of 87.

Figure D

Total Cost of Metrication as Percentage of Value Added by Manufacture in 1969



Since the cost data do not seem amenable to a straightforward statistical analysis they may be interpreted better by application of a method which in the field of literature is called higher criticism. The methods of higher criticism are qualitative and not quantitative. They involve consideration of the point of view of the individual who supplied the data, the guidance he had in preparation of his estimates and what prejudices, if any, may have entered into his conclusions.

In applying this technique to evaluation of the data reported, the critic must be guided by his own knowledge of the particular areas involved and by the advice of his colleagues who are informed in these areas. He must be in a position to judge how well the guidelines established for making the estimates were followed and where possible, from his personal knowledge and his acquaintance with the individuals making the reports, judge how well they understood the solutions which are available for their problems. He must take into account the amount of effort which entered into preparation of the reports. While this approach may yield a better estimate of actual costs, it cannot lead to any meaningful limits on the uncertainty of the estimates.

There is no evidence that the reported costs were strongly influenced by prejudice for or against increasing metric usage by those making the reports. That some of the higher estimates resulted from apprehension of the problems engendered by increasing metric usage there can be little doubt. It is clear that companies with extensive experience in metric usage tended to report lower costs than those with little or no experience in metric usage.

In spite of efforts to instruct respondents that double counting should be avoided, namely that a company should report on its own particular costs, in many cases it appears that high estimated costs were the result of allowing for increased cost for replacement parts of machinery. Companies supplying such machinery have included in their estimates the cost of maintaining replacement parts for existing machinery, which they must do anyway, and which often continues for long periods of time after the machinery itself has become obsolete. Only by very careful detailed analysis of a particular company's problems can this double counting be avoided, and in many cases companies making the reports have not adequately examined these problems.

The very wide range in the estimates, 900-fold, has been mentioned before. While we do not believe that such a range involves realistic estimates, nevertheless, wide ranges in estimates of cost seem realistic in many cases and can be justified by examining the particular circumstances involved.

Considerable understanding of the disparate estimates can be obtained by considering individual cases, particularly the outliers; that is, those where estimates differ greatly from others in the same industry or similar industries. In some cases it was possible to interview the people who had prepared the reports and obtain insight regarding the bases of these estimates. In other cases telephone conversations were held with the individuals responsible for preparing the reports. Sometimes it was possible to arrive at conclusions by studying the questionnaires themselves.

Several of the reports submitted in the 2000 to 3200 industries deserve special comment. In the food processing industry, the 2000 group, five reports were received, four of which group around an estimated cost of 1 percent. The fifth is a conspicuous outlier giving an estimated cost of 12 percent. Considerable doubt must be placed on the reliability of the high estimate in this case. The reporter estimated that 85 percent of the cost would be in manufacturing and quality control, and stated that only 1/2 of 1 percent of the cost of production went into the procurement of raw materials. Since in the food industry as a whole the cost of materials is nearly 3/4 of the value of sales, there is reasonable doubt that the individual preparing the report for this company really understood the problem before him. It seems that the major cost in the food industry, if metrication should take place, would be in labeling and changes of package sizes. In many cases package sizes would not be changed and only changes in labeling would be necessary. Of course, inventories of materials would be kept in metric language but this is essentially a software change.

No vigorous efforts were made to include textile and garment manufacturers in the cost survey, because preliminary investigations had shown that the problems of increased metric use in these fields should be very slight; however, one garment manufacturer volunteered to participate in the survey. A telephone conversation held with a representative of this company prior to filling out the questionnaire is interesting. The individual making the report was concerned that if the country were to go metric, it might be necessary to replace all of the heads on sewing machines to adapt them to metric needles. It was explained that it would probably be advantageous to retain the present heads on machines, replacing them with metric heads if such were produced at some future time as new machines are purchased, and double stock needles. Then came the question, "Where do you buy your needles now?" "We buy them from Germany." "Then aren't they already probably metric?" "Yes, I suppose they are, we hadn't thought of that." The estimate subsequently supplied by this respondent was 0.8 of one percent of value added.

Two paper manufacturers reported costs of 1.4 percent and 29 percent. It is difficult to understand how this 20-fold spread in costs in this industry could arise, or how any credence could be placed in the higher estimate since the only changes the industry might have to make would be in the setting of cutting knives or the introduction of metric scales on the knife settings if the industry were to metricate.

Special attention should be given to the chemical industry, and an industry closely allied with it as far as metrication problems are concerned, the petroleum refining industry. The pharmaceutical industry, which is classed as a chemical industry, has already converted to the metric system. The experience of pharmaceutical manufacturers is that the cost of conversion was largely recovered during the first year of operation under the metric system, because of the greater convenience of metric units of weight and measure. Pharmaceuticals account for 17 percent of the total value added in the chemical industries. It does not follow that the problems will be as simply solved in the other chemical industries as they were in the pharmaceutical industry. Individuals engaged in these industries exhibited apprehension that it might be very difficult to replace, repair, or redesign equipment with metric pipe sizes, metric boiler sizes, etc., if the country were to change to the metric system. Many of the plants are equipped with automatic measuring equipment which would have to be changed or readjusted if packaging on products were to be done in rational metric units. Although apprehension regarding replacement, repairing, and redesigning may have led to higher estimates, no comment can be made on the realism of these estimates without more detailed study of the industries involved. It is our opinion that the cost studies in the industry groups 2000 to 3200 were not carried out in the same depth as were those conducted in other industries, which will be described later.

In the 3300 industries, primary metals, very disparate results were obtained. The steel industry estimated costs from 1.8 percent to 10.5 percent and one company in the nonferrous metals industry estimated cost of metrication at 41.7 percent. This very high estimate, it was learned from telephone conversations, was based on the fact that the principal costs in manufacture are derived from repair of machinery and the reporter anticipated that these repairs would be more costly if the country were to go metric, since only metric parts and no customary parts might be available for repair purposes. On the contrary, another company engaged in nonferrous products reported a very low cost estimate of 0.57 of one percent. The low estimating company has had extensive experience in metrication through its international connections. No primary metals industry should be more severely impacted than the steel industry. In the rolling of sheet metal to metric sizes no particular problem is involved since the rollers can be readily set to the nearest dimensions in customary units and produce a product within metric specifications. The 41.7 percent estimate is therefore regarded as unrealistic and not based upon the premises established for the study.

In the fabricated metals industries, excluding machinery (group 3400), wide ranges in estimates were obtained. Firms engaged in the manufacture of cans, industry 3411, gave a range of from 0.9 percent to 40 percent, over a 40-fold difference in estimate. It does not seem likely that any program of metrication in this industry would lead to substantial changes in the size of cans now being produced. Many of the cans, of which there is a proliferation of sizes now, could be used in the packaging industries by simple acceptance of existing sizes or by changing height rather than diameter of the can. This major industry group also includes the producers of fasteners, who have long viewed with alarm any tendency of the country to change to the metric system. Estimates from companies engaged in this industry range from 14.2 percent to 38 percent. A visit was paid to the company making the lowest estimate. Incidentally, this company is strongly prometric and voted on the A form of the Questionnaire in favor of a mandatory program of metrication based on legislation. A large part of the estimated cost was based upon the need to replace gauges if a transition to the metric system were to occur. While the gauges in a measurement laboratory of a screw thread company might require replacement due to metrication before they had served out their useful lives, the major cost of gauges is involved in monitoring production on the shop floor. In these cases gauges must be replaced every 2 months to 2 years depending upon the magnitude of the particular product run. In any orderly transition to the metric system such gauges would be replaced in the normal cycle of replacing gauges as the product line gradually shifted from customary to metric standards. It must be concluded that even this company, which was favorable to a change to the metric system, estimated the cost higher than called for.

If the proposal of the Industrial Fasteners Institute for a new series of screw threads based on metric standards plus some modifications to make them more effective in supplying the needs of American industry is accepted the entire cost estimate of metrication in the threaded fastener industry must be revised.

One company in industry 3494, valves and pipe fittings, estimated a cost of 189 percent. Two other companies in this industry reported costs of 7.2 percent and 14.9 percent, giving a 24-fold range in the estimates. Such disparity can only be the result of differences in assumptions which the companies made in preparing their estimates. A large part of the cost of the high estimator was attributed to engineering and design. The company has considerable experience in fabricating metric products. It set 15 years as an optimum period for a transition to metric products. Peculiarly enough, the company thought that the cost would be somewhat less if the transition were to occur in ten years in a national coordinated program of metrication. It seems inconceivable that valves and pipe fittings would be substantially changed in a period of fifteen years. There would be a need to maintain replacement parts for existing valves and pipe fittings. The standards for internal workings of valves are proprietary standards and pipe fittings in metric countries are not different because they are metric, but are different because of adoption of the British standards set forth by the British mechanical engineer Whitworth which involves a different thread form from that used in the United States. These are not *per se* metric problems but problems involving differences in national standards. Although it appears that costs in this industry would be substantial, it does not seem that the higher estimate given is based upon a realistic approach to any transition to use of metric measurement and metric engineering standards.

In the nonelectrical machinery industries there are three reports in which the estimates were above 100 percent of the value added. These estimates were made by one small business manufacturer. A visit to this firm revealed that the proprietor who made the report had gone well beyond the guidelines set down for estimating. He had assumed that in the course of metrication, materials and stock sizes which were regularly used by his company would no longer be available and he would have to redesign his equipment to use the new metric standards as they came into existence.

In the analysis procedures, either by taking medians or by weighting the estimates by company productivity, such estimates do not enter substantially into the evaluation of total overall cost of metrication. However, in the forthright discussion of these estimates, it is necessary to call attention to these problems since they may well have pervaded the entire study. In the 3500 industries, attention should be called to two independent reporters whose estimates amount to 48 percent and 38 percent of value added by manufacture. These are companies engaged in the manufacture of turbines (industry 3511). In the United States this industry has always used the customary units of measurement. Preliminary studies showed that those engaged in this industry have extreme apprehension of any change in the measurement system as regard their products. If the cost to these activities is as great as is represented, it seems that no change to metrication should be involved in their future planning. They should continue to produce what they are producing now, and if occasion demands, specify the characteristics of their devices, external dimensions and mating parts in metric by a simple translation from one system to the other just as is being done in Britain. Furthermore, those engaged in this particular industry do not depend upon replacements from local hardware but rather from parts designed to meet the particular needs of the device involved.

Particular attention is called to industry 3522, farm machinery, where four estimates all fall below 3.2 percent. These low estimates come from companies which have extensive experience in metric usage and are in sharp contrast to one estimate of 19 percent in the construction equipment industry, 3531. There appears to be little difference in the metrication problems confronting farm machinery equipment and construction equipment. Other estimates from industry 3531 range from 1.2 percent to 2.8 percent.

Wide ranges in estimated costs occur also in industry 3534, elevators and moving stairs. The lowest estimate, 3.7 percent, is less than 1/10th of the highest estimate, 42 percent. The high estimator ascribed most of his costs to retraining of personnel which amounts to about $5,000 per employee. In a telephone conversation with the reporter from this company we were assured he felt this to be a realistic estimate, but it is entirely out of line with all other estimates of retraining personnel, and does not correspond to costs which have been experienced in some of the plants visited in England where metrication has proceeded at a fairly rapid pace.

A large range in estimates was obtained from industry 3541, machine tool, cutting type, and 3542 machine tool, metal forming type. The lowest estimate was 5.3 percent and the highest 65 percent, an over 10-fold range in estimates. The plants of the lowest estimator and of one of the higher estimators were visited after the reports were turned in to ascertain the basis of their estimates. The higher estimator submitted the guidelines which had been followed in estimating, which are essentially identical to those set forth in the general instructions, but included particular guidelines for the product involved. They are as follows:

3541

METRIC STUDY ASSUMPTIONS MANUFACTURING INDUSTRY QUESTIONNAIRE

Several assumptions must be made as guidelines in establishing costs for a possible conversion to the metric system. The assumptions made to date are listed.

1. The metric system will be introduced on new designs only.

2. A metric conversion will include metric fasteners.
3. Drawings will show single (inch or mm) dimensions only.
4. Metric material will be stocked on a volume availability and economic basis.
5. The inch involute spline standard will be adopted by ISO and we will continue to use the inch series.
6. Machine tool tapers (B&S, Morris, and the National Machine Tool Taper) will not be changed.
7. Personal tools will continue to be purchased by individuals; however, the company will provide a method for ordering these tools at a "friendly price."
8. Arbors and cutting tool holders will eventually be metric.
9. Electric power will not be changed and will remain 60 cycle.
10. Data processing and numerical control cards and tapes will not change in size or format.
11. Existing products as well as new products will be designed to accept inch or metric input throughout the conversion period.

This indicates, among other things, the thoroughness with which the study has been made. Most of the costs in this company were attributed to manufacturing and quality control. These estimates were high due to the anticipation of an increasing loss due to scrap and errors in adjusting to metric measurement in the manufacturing process. The high estimating company thought that there would be a 15 percent increase in losses per year due to this cause for the first 10 years, dropping to 5 percent during the next 20 years of a protracted conversion. The low estimator considered that there would be no increase in losses due to scrap in the process of going metric because metric designs would be used only in new machines and whenever a new machine is introduced in the product line there is an increase in scrap loss anyway, and use of metric measurements would not increase this loss. Incidentally, the low estimator had been visited by members of the study team before the cost survey was undertaken and received much more indoctrination in problems of metrication than the other companies reporting in this product line. It is our opinion that many of the estimates supplied from machine tool industry are excessive, and the true cost of a program of metrication would be somewhat nearer the low figures than the high ones.

In the electrical machinery industries, a wide range of estimates obtained, from 0.2 percent up to 32 percent, a 160-fold range. In industry 3611, electrical measuring instruments and test equipment, a 50-fold range was reported. The lowest estimate, 0.2 percent, is considered to be a valid estimate for several reasons. During the initial phases of the metric study this company voluntarily submitted a cost estimate for conversion, based on a transition in three years, which would involve a revision of all their drawings in a complete conversion to metric units of measurement. The cost estimated on this basis was six times that finally submitted, based on the guidelines set forth in the instructions to respondents to the questionnaire. But this company and another one reporting in the same group with a cost estimate of 0.6 percent do not represent the industry as a whole, since they are involved in the production of very high quality, expensive equipment most of the cost of which is involved in calibration of electrical quantities where the units of measurement are in the International System of Units. While these low estimates seem valid for the companies involved, they probably do not represent the industry as a whole. Nevertheless, the highest estimate in this group, 10.7 percent, seems unrealistic.

In industry 3612, power distribution and specialty transformers, an 8-fold range was reported, and in industry 3622, industrial controls, with three companies reporting, a 24-fold range was obtained. It was learned by a visit to one of the high reporting companies in this group, that their equipment is redesigned over a cycle of every three or four years, and that the changes in equipment are oriented toward decreasing the size of the equipment, that is miniaturization, and to use of non-mechanical parts wherever possible. It appears that this high reporting company had assumed that at some specified time it would be required to change all design parts to meet metric specifications. It must therefore be concluded that the high cost estimates involved are not realistic.

Industry 3641, electric lamps, exhibited a 15-fold range in estimates. What may have led to the high estimate (32%) in this industry surpasses the imagination because if the United States were to substantially convert to the metric system there would still be a need for lamp bulbs to suit American sockets which have been and will continue to be in use for many decades. Fluorescent lamp standards that have been employed in the industry for many years both domestically and abroad are substantially the same. Any dimensional or base changes will take place gradually over a period of many, many years. A problem this industry has encountered is the need to design for differences in voltage supplies in various countries in which the lamps will be used. This is not a metric problem but one that arises from the lack of international standardization of power supplies which will not be changed because of vast investments in existing power systems.

The most thorough studies on the cost of metrication were conducted by companies engaged in the manufacture of transportation equipment, particularly automobiles and trucks. Reporting in industry 3711 are three companies two of which are giants of the automotive industry of the world. We are well acquainted, professionally, with those responsible for submitting the reports and conducting the investigations. All of the companies reporting have extensive experience with metrication, since they operate plants both in the United States and abroad. Yet, even in this field the cost estimates range by a factor greater than 6. In this case, the low estimator, 1.3 percent, should be given a low weight inasmuch as this company is engaged primarily in the manufacture of trucks and is a small company in this field as compared with the larger reporters in this industry. It was our privilege to talk with the people responsible for the surveys in these particular companies extensively before the surveys were made. For this reason we have a high degree of confidence in the estimates. From the higher cost estimates that were made by two companies, 8.0 percent and

4.2 percent, we deduce that the cost of metrication in the passenger car automobile industry over the period of transition would be about 6 percent of value added. If this cost is spread evenly over a period of 12 years, which is the optimum transition period for automotive change, and if the percentage added cost of metrication of suppliers to the automobile manufacturers is about the same as that of the manufacturers themselves, the cost of metrication borne by the consumer would be about 1/2 of 1 percent of sales value, that is about $15 on a $3,000 automobile. It seems that these cost estimates, which are based upon very serious studies by the companies reporting, represent a realistic estimate of the cost involved in a fairly complicated product such as automobiles which account for a very large part of the gross national product. Less complicated products, such as home appliances, would probably have smaller cost since the problems of interfacing of metric with nonmetric parts will not be as involved. But some industrial areas, such as the manufacture of machine tools, will find costs somewhat greater because of the practice in the machine tool industry of gearing a particular product to a user's specifications.

In the 3800 group of industries, estimates ranged over a 90-fold cost factor, the highest estimate coming from industry 3821, mechanical measuring and control instruments, and the lowest coming from industry 3841, surgical and medical instruments and apparatus, which is already largely metric. The 3800 group is dominated very largely by estimates from the photographic industry, number 3861. The cost estimates in this industry alone cover a 5-fold range.

Only two companies reported in the 3900 group, which includes miscellaneous manufacturing industries, such as jewelry, musical instruments, toys, sporting goods, etc. It is difficult to see why any substantial cost of metrication would be involved in these industries. It seems unfeasible to draw any serious conclusions from the two companies reporting in the field of jewelry and other similar industries not elsewhere classified, numbers 3911 and 3999, their estimates being 1.3 and 5.9 percent of value added, respectively.

Facing these disparate estimates, the study group is compelled to arrive at some overall estimates of a cost to all manufacturing industries. These estimates are likely to be high for several reasons:

(1) Respondents were requested to estimate on the basis of a "hard" change, that is, one in which a transition to metric based standards and metric based modules would occur, rather than a "soft" change, that is, one in which only a change in language would be involved. Many companies might find the latter alternative as effective and more economical.

(2) The companies that participated in the cost survey were not selected on a random basis—quite the contrary. It was realized from the start that because of the intricacy and expense of making metrication cost estimates a random sample could not be obtained. It was therefore decided to concentrate on areas where metrication costs could be expected to be high and to determine those costs. Preliminary investigations had shown which industrial groups would be more severely impacted by a change to the metric system than others. The most severely impacted

group seemed to be the industries in the 3500 group. For this reason a disproportionate number of companies engaged in these industries were solicited to participate in the survey. In addition, the responses to requests for participation were more favorably received by these groups than by less-highly impacted groups. For example 13 machine tool companies, industry 3541, metal cutting type, and 3542, metal forming type, are represented in the survey. These two industries in 1967 accounted for only 0.7 percent of value added in the manufacturing industry, yet they represent 8 percent of the companies sampled. Since the basic sample of companies solicited for participation in the cost survey is not a random sample and is known to include an overbalance of high-cost estimates, treating the reports as if they came from a random sample is bound to give an overestimate of the costs.

A conventional method of handling the data would be to regard each company's estimate of cost for a given product as a datum and weight it according to the value of the product produced by the reporting company. The weights used were the same as those used in the Westat analysis (see p. 60) ranging from 0.3 for a company reporting sales of less than $1 million to 3000 for a company reporting sales in excess of $1 billion. Combining these weighted results within each of the major industry groups given on page x, yields an average percentage cost of metrication for that group.

This average, when multiplied by the value added by manufacture as given by census figures, is one estimate of total cost of metrication for that group. The overall total was then multiplied by 300/259 to correct the results to 1969. This treatment of the data is very similar to that employed by Westat but the industries are grouped differently.

The results of this treatment of the data are given in table 1. This table shows the estimated cost of complete metrication to the manufacturing

Table 1. Estimated cost of metrication in manufacturing industries based on weighting by value of product

Industry group	Cost as percentage of value added (weighted average)	Value added in 1967 (billions)	Cost (billions)
2000–3200	3.7	$125.0	$4.63
3300	22.1	20.1	4.44 *(1.47)
3400	6.0	17.1	1.03
3500, 1900	14.0	32.7	4.58 *(3.56)
3600	9.2	24.9	2.29
3700	8.8	28.9	2.54
3800	8.6	6.1	0.52
3900	5.1	4.5	0.23
Total		259.	20.3 *(16.3)

Total cost corrected to 1969: $\frac{300}{259} \times 20.3 = 23.6$ (18.9).*

* Revised cost estimates by eliminating reports from two companies, Industries 3331 and 3531.

industries and the change in this cost estimate if two of the responding companies had not reported. The reliability of these two reports was questioned in the critique of the estimates. Had these two companies failed to report, the estimated cost in the manufacturing industries would have been lowered by 20 percent. Thus, if all of the reports are taken at face value the overall cost of metrication for the manufacturing industries is $24 billion while the elimination of two companies reduces this figure to $19 billion.

The effect of weighting by value of product is to attribute to each company's estimate of costs a reliability proportional to the company's sales of that product. Is a company which reports a sales value less than $1 million to have its estimate considered as 1/10,000 as reliable as that of a company with a sales value of over $1 billion? Is the estimate of the smaller company thus to be so heavily discounted?

The study team recognizes that some of the large companies have devoted greater efforts to the study, have been more fully indoctrinated regarding the hypotheses than the small companies. But this is not true for all of the large companies included in the survey.

An alternate procedure would be to assign the same weight to all reports, and follow the same procedure. The results of this calculation are shown in table 2 together with the change in the cost estimate obtained by eliminating the reports from five companies which had been judged as excessive in the critique. The overall cost obtained in this way amounts to $30 billion, which reduces to $22 billion when the five suspect companies are eliminated, a decrease of 27 percent.

Since both of these methods lead to results that are greatly affected by elimination of just a few reports, both estimates derived by conventional statistical procedures may not be reliable estimates. But it should be possible to bracket the possible costs of metrication by less rigorous techniques.

Table 2. Estimated cost of metrication in manufacturing industries based on unweighted averages

Industry group	Cost as percentage of value added (unweighted average)	Value added in 1967 (billions)	Cost (billions)	
2000–3200	4.4	$125.0	$5.50	*(3.75)
3300	10.0	20.1	2.01	*(1.00)
3400	28.1	17.1	4.81	*(2.68)
3500, 1900	22.8	32.7	7.45	*(5.55)
3600	10.0	24.9	2.49	
3700	7.7	28.9	2.22	
3800	13.9	6.1	0.85	
3900	3.6	4.5	0.16	
Total		259.	25.5	*(18.7)

Total cost corrected to 1969: $\frac{300}{259} \times 25.5 = 29.5$ *(21.6)

* Revised cost estimates by eliminating four reports from companies in industries 2043, 2621, 3331, 3494, and three reports from one company in industries 3535, 3555, and 3559.

The data themselves within the individual industrial groups do not appear to fit a normal or Gaussian distribution but rather a log normal distribution. It is for this reason that the points in figures A to D were plotted with a logarithmic ordinate scale. Arithmetic averages of such data, either weighted or unweighted, are very strongly affected by the high values. Thus one cost estimate of 100 percent has about 10 times as much effect on the arithmetic average as one estimate of 10 percent.

Since there is a commonality of problems within each industry grouping the estimates within each industry grouping should be approximately the same. Assume that in each group; (1) ¼ of the companies over-estimated and ¾ underestimated, (2) ½ of the companies over-estimated and ½ underestimated and (3) ¾ of the companies over-estimated and ¼ of the companies underestimated. These demarkation values are known as the upper quartile, median, and lower quartile values respectively. For the industry groups 2000 to 3200 (see fig. A) the upper quartile, median, and lower quartiles fall at 5.2 percent, 1.7 percent, and 1.0 percent respectively.

Calculation of estimated costs of metrication for the entire manufacturing industry by using the median and quartile values is carried out as in the previous two calculations. This treatment leads to the following, corrected to 1969: Assumption (1) $32.6 billion, (2) $14.4 billion, and (3) $6.2 billion. (See table 3.)

Table 3. Estimated cost of metrication in manufacturing industries using the upper quartile, median, and lower quartile as estimates

Industry group	Percentage of value added			Value added in 1967 (billions)	Total cost (billions)		
	Upper Quartile	Median	Lower Quartile		Upper Quartile	Median	Lower Quartile
2000–3200	5.2	1.7	1.0	$125.0	$6.50	$2.12	$1.25
3300	10.5	5.0	1.8	20.1	2.11	1.00	0.36
3400	25.0	14.0	7.2	17.1	4.28	2.39	1.23
3500, 1900	23.0	12.5	3.7	32.7	7.53	4.09	1.21
3600	14.3	3.6	2.2	24.9	3.57	0.90	0.55
3700	9.5	4.2	2.2	28.9	2.75	1.21	0.64
3800	19.7	7.2	2.7	6.1	1.21	0.44	0.16
3900	5.9	3.0	1.0	4.5	0.27	0.14	0.05
Total					28.2	12.3	5.4
Corrected to 1969					32.6	14.3	6.2

Certainly the highest of these limits is excessive and while the lowest may be too low it is reasonable to assume for reasons previously cited that the total costs will be between the median and lower quartile estimates. This is particularly true if in many areas a "soft" change is made instead of a "hard" one.

SUMMARY

Because of the small number of respondents to the cost questionnaire, and the large uncertainties involved, there is considerable doubt as to whether the estimates of the cost of metrication as reported by the responding companies can be used as a reliable basis for computing the cost to the entire country of a program of metrication. The estimates are indeed only estimates made on varying bases as far as the reporting companies were concerned. The Metric Study Group is greatly indebted to those who have participated in the survey. This attempt to interpret the results of their reports should in no way be considered a reflection on the sincerity of the effort that they have contributed to the study. Anyone regarding the estimates from a completely unimpassioned point of view must come to the conclusion that most of the reporters were "running scared" in estimating metrication costs. After all when the costs of metrication as deduced from the various ways in which the data have been handled are placed in perspective with regard to the gross national product averaged over a period of 10, 20, or 30 years, as may be required for the particular industries involved, the increases in cost to the ultimate consumer who must in the end be obliged to pay these costs are relatively small as compared to the fluctuations in the cost of living and the normal rise in the value of manufactured products resulting from normal processes of inflation.

SUMMARY

A. METRIC USAGE

In 1970 about 10 percent of U.S. manufacturing companies made some use of metric measurement units and/or metric measurement standards. As one might expect, the proportion of large companies that use the metric system is substantially higher than the proportion of small companies. Less than 10 percent of companies with less than 50 employees use the metric system whereas more than 30 percent of those with 2,500 or more employees are metric users. Thus, it turns out that even though approximately 10 percent of the manufacturing companies are metric users, nearly 30 percent of total manufacturing employment is represented by companies using the metric system.

Results of the survey indicate that metric use is of modest but growing importance. Respondents anticipate that there will be some increase in the number of companies using metric measurement and a considerable increase in the extent of metric application by companies already using the metric system. A larger proportion of companies using the metric system in 1970 predicted an increase in their metric usage from 1970 to 1975 than reported such an increase from 1965 to 1970 in four of five reported types of metric activities. The reverse was true for estimated decrease in metric usage during these periods of time. Furthermore, companies using metric measurements or standards in 1970 showed either no change or an increase in average percentage of metric use between 1965 and 1970 and an increase between 1970 and 1975 – for each of the five activities.

Of the manufacturing concerns represented in the survey that use metric units, a majority apply this use in research and development and some aspects of the manufacturing process. More than a fourth of these companies use metric measurements in their shop drawings, but only about 5 percent of these companies use metric dimensions exclusively. Nearly 80 percent of these companies use dual dimensions and about 60 percent use both metric and customary shop drawings.

In addition to mating with standard metric design components, the two most frequently given reasons for metric use or planned use were (1) its advantages resulting from having one basic system of measurement in worldwide production and (2) simplification economies due to metric use. This is important, since one-third of the manufacturing companies (with two-thirds of manufacturing employment) export at least some of their output and almost all foreign countries are now under the metric system or have announced plans to adopt the system in the future. Larger companies, the majority of which export, reported more need to modify their products to metric for export than did smaller companies. Such modifications were predominantly in the use of metric measurement units in labeling, descriptions, and instructions. Finally, as a rule, manufacturing under agreements or operation in foreign countries was found to involve substantial use of metric units and/or metric engineering standards.

With respect to the anticipated effect of metrication[1] on foreign trade about 1/6th of the manufacturing companies (with about the same proportion of manufacturing employment) anticipated an increase in export sales, while about one company in 20 (with about the same fraction of employment) thought their sales would be adversely affected because of increased imports.

B. ADVANTAGES AND DISADVANTAGES OF METRIC USAGE

Metric users among manufacturing companies in the United States have experienced both advantages and disadvantages of metric use. Simplified specifications, cataloguing, and records; improved intracompany liaison and records; and training of personnel were cited as the chief advantages. Difficulty in obtaining metric-sized parts and tools, dual dimensioning or duplication of drawings, training personnel, and more production items in inventory were cited as the most important disadvantages. Although about three-fourths of the metric user companies did not indicate that metric use was either advantageous or disadvantageous, just over twice as many of the metric users who did so indicate believed that advantages outweighed disadvantages as believed the reverse.

Under a coordinated national program, present nonmetric users generally saw more areas in which there would be disadvantages than advantages. With a coordinated national program (as measured by employment) metric users were two to one in indicating areas of advantage as against areas of disadvantage, while nonusers were nearly two to one in the opposite direction. Since nonmetric users account for more total employment, they slightly more than offset the views of metric users in the sum.

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[1] Throughout this report and all other reports of this series (NBS SP 345-) metrication is defined as follows: Any act tending to increase the use of the metric system (SI), whether it be increased use of metric units or of engineering standards that are based on such units.

The following estimates regarding costs and savings attributable to increased metric usage are subject to greater uncertainty than are the other estimates in this report because of small sample size, the difficulty of making such cost and savings estimates, and possible bias of companies that reported their results as contrasted to those that did not report. On the basis of each company using its reported optimum time period, it is roughly estimated that the total cost of metrication for manufacturing companies accumulated over a period of years is $25 billion in 1969 dollars. This estimated total cost of metrication is about 8 1/2 percent of the value added by manufacture for the year 1969. The estimated cost of metrication as a percentage of value added was higher for manufacturers of standard parts or standard materials than for manufacturers of other products.

In addition to the cost of introducing metrication, there is a temporary continuing annual cost to producers of standard parts or materials to maintain both customary and metric capability until transition to the metric system by the companies they supply is substantially accomplished. A very rough estimate of the cost of maintaining this capability is about a half-billion dollars a year, or perhaps an accumulated total on the order of five billion dollars for the transition period.

About a fourth of the companies responded that they would expect significant tangible savings from a transition to metric usage, and for these, it would take between 12 and 15 years, on the average, to achieve savings equal to the net added cost that would be incurred during the period of transition to the metric system.

The optimum number of years in which transition from customary units to metric units can be accomplished was reported at 10 years or less for companies accounting for about 82 percent of the estimated value added by manufacture. The average number of years (a weighted average, with weights based on value added by manufacture) was 9 1/2 years.

The estimated cost for metrication would be about 10 percent higher for transition under a voluntary program in a 10-year period, as compared with transition under a voluntary program in which each company would choose its optimum time period.

C. COMPANY ATTITUDES AND OPINIONS TOWARD METRICATION

The attitude of manufacturers is mixed as to whether the increased use of the metric system in their own industry would be beneficial. More companies in total, by a small margin, are against increased use in their own industry rather than for it. However, larger companies, which tend to be more experienced with the metric system, are more favorably disposed toward it so that a measure based on the economic importance of respondents in terms of value added by manufacture would favor increased metric usage in their own industry.

On the key question as to whether increased metric usage would be in the best interests of the United States, manufacturers leave no doubt—they preponderantly respond in the affirmative; the majority of companies, large and small, in all broad industry classes, currently using and not using the metric system, all respond affirmatively. Over-all, of the companies answering the question, 70 percent (with 80% of manufacturing employment) believe that the best interests of the United States would be served by increased metric use. Based on the assumption that increased metric usage is found to be in the best interests of the United States, 50 percent of the companies answering the question expressed an opinion that a coordinated national program based on voluntary participation is the course that should be followed, and 43 percent stated the best course would be a mandatory program based on legislation. In all, therefore, 93 percent of those responding to this question were in favor of a coordinated national program, pursued through voluntary participation or mandatory legislation, while only 7 percent favored an uncoordinated approach.

I. INTRODUCTION

The metric system of measurement was developed in 1790 and gained immediate worldwide attention. In the ensuing years, it has become the dominant world measurement system. Its growth is demonstrated by the fact that over 80 nations have adopted the metric system. Increasing world trade and technological advances have spurred the use of the metric system to the point where metric countries account for 80 percent of the world's population and 60 percent of the world's gross national product.

In 1866 Congress passed a bill that permitted use of metric measurements in the United States. Since that time usage of the metric system in the United States has gradually increased, and implications of its usage relative to foreign trade have become increasingly important. A bill was passed by Congress and signed into law by the President of the United States in August 1968 authorizing the Secretary of Commerce to conduct a program of investigation, research, and survey "to determine the impact of increasing worldwide use of the metric system on the United States" and "to appraise . . . economic advantages and disadvantages of the increased use of the metric system . . . in specific fields and the impact of such increased use on those affected."

The Secretary of Commerce named the National Bureau of Standards to carry out this task, which was done through an organizational unit called the U.S. Metric Study Group. The U.S. Metric Study Group conducted a study of a number of United States private, industrial, and government sectors to determine the impact of metric usage on each of these sectors. One of the most important of these sectors is manufacturing. This report presents the analysis and results of a survey of manufacturers conducted by the U.S. Department of Commerce, National Bureau of Standards.

Three basic questions relative to manufacturing constitute the direction of the study. These are:

> What is the present impact within the United States of increasing worldwide use of the metric system?
>
> What would this impact be in the future, assuming that the use or nonuse of the metric system continues as at present, with no coordination among the various sectors of the society?
>
> Alternatively, what would be the effect of a coordinated national program to increase the use of the metric system?

It was felt that the best approach to answer these questions was to conduct a survey consisting of two parts. The first part was designed to solicit general information concerning metric usage and attitudes toward the metric system. The second part was concerned with more difficult issues dealing with metrication cost and timing. Information was solicited for each part by a questionnaire.

Included in this report are a summary section based on the study, an introduction (ch. I), the detailed findings and analyses of results (ch. II), and appendices. A discussion of the manufacturing sector of the United States, some of the background of the survey, and design of questionnaires and samples are included in the introduction. The presentation of the detailed findings and analyses is structured around the three basic questions (above) to which the study was directed, plus a discussion of manufacturers' views on metrication, other general comments, sampling errors, and time and cost implications. The appendices contain a detailed discussion of sample selection, estimation and variances; copies of the questionnaires that were used in the survey; and a listing of SIC categories.

Detailed tabulations upon which the findings and analyses were based are found in appendix E.[1] These include some cross-tabulations of the questions.

The remainder of this introductory chapter is presented in four sections:

A – The Manufacturing Sector
B – The Survey Background
C – Design of Questionnaires – Form A and Form B
D – Design of Samples

The first part of section A discusses the definition of the manufacturing sector. Also discussed are factors that indicate manufacturing's great importance to the U.S. Metric Study. A discussion of the historical concern of the manufacturing sector regarding metrication in the United States is the concluding portion of section A.

The Survey Background constitutes section B of the introduction and covers five related topics leading up to the actual survey instrument and sample design. The Standard Industrial Classification (SIC) structure is explained, along with reasons for use of the SIC codes for the survey. Part of the survey background included visits by National Bureau of Standards personnel to manufacturing plants to exchange information on metrication problems, and the outcome of these visits is presented. Several alternative survey methods, such as individual company interviews, the use of industry consultants, and utilizing mailed questionnaires, were considered and the merits of these are discussed. The selection of the survey method was influenced by some corresponding efforts of the American National Standards Institute (ANSI).

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[1] App. E, which consists of printouts of the detailed data on which this report is based, has not been printed but a limited number of copies have been reproduced and are available at $6.00 each from the National Technical Information Service, Springfield, Va. 22151. Copies may be ordered under NTIS No. COM-71-00517.

The reasons for deciding to use part A and part B questionnaire forms as well as other factors relative to the survey instrument design are covered in section C of the introduction. The role of industry consultants and the Office of Management and Budget (formerly Bureau of the Budget) advisory panel regarding the questionnaire design is also described.

Section D of the introductory chapter is a summary of the sampling aspects of the survey. The employment size classes and the three SIC categories used for defining the survey universe and for sample selection purposes are explained and distinguished from the revised SIC categories that were used for the tabulations and analyses as presented in chapter II of this report. Discussion of the part A sample design covers the definition of the part A universe, sample selection, the response to the questionnaire mailings, the sampling of nonrespondents, and a reference to appendix A for a detailed description of the sample selection, estimation and variances. The last topic in section D deals with the part B sample.

A. THE MANUFACTURING SECTOR

1. DEFINITION OF THE MANUFACTURING SECTOR

Manufacturing, as an economic division of industry, is defined in the Standard Industrial Classification Manual as including:

> . . . those establishments engaged in the mechanical or chemical transformation of inorganic or organic substances into new products, and usually described as plants, factories, or mills, which characteristically use power-driven machines and materials handling equipment. Establishments engaged in assembling component parts of manufactured products are also considered manufacturing if the new product is neither a structure nor other fixed improvement.
>
> The materials processed by manufacturing establishments include products of agriculture, forestry, fishing, mining, and quarrying. The final product of a manufacturing establishment may be "finished" in the sense that it is ready for utilization or consumption, or it may be "semifinished" to become a raw material for an establishment engaged in further manufacturing. For example, the

product of the copper smelter is the raw material used in electrolytic refineries; refined copper is the raw material used by copper wire mills; and copper wire is the raw material used by certain electrical equipment manufacturers.

The materials used by manufacturing establishments may be purchased directly from producers, obtained through customary trade channels, or secured without recourse to the market by transferring the product from one establishment to another which is under the same ownership. Manufacturing production is usually carried on for the wholesale market, for interplant transfer, or to order for industrial users, rather than for direct sale to the domestic consumer.

Printing, publishing, and industries servicing the printing trades are classified as manufacturing industries.[2]

2. THE IMPORTANCE OF MANUFACTURING

In the United States the manufacturing sector industries account for nearly one-third of the gross national product. Manufacturing assumes particular importance as a part of the U.S. Metric Study not only because of its economic size, but also for a number of other reasons. Many manufactured commodities are produced to specified sizes and shapes, often involving highly precise dimensioning. These dimensions are prescribed by custom or engineering standards which have been developed over the years. Factory products are, in general, highly transportable and enter freely in domestic and international trade. They account for approximately eighty percent (80%) of the total value of U.S. exports. Much of the contribution to the economy from other industry divisions, such as wholesale and retail trade and transportation, is derived from the handling and distribution of the products of the manufacturing industries.

Manufacturing differs from other product industries, such as agriculture, forestry, fisheries, and mining, in that the products of these other industries are usually bulk products and trade in them is conducted in terms of the weight or volume of the product. A difference in the units of measurement involved when these products enter into foreign trade is generally taken care of by a simple translation of the units, just as the monetary values are translated for differences in currency. Although some of the products of the manufacturing sector are also bulk products, these are, in many cases, packaged in containers whose sizes and shapes have been established by custom, law, or engineering standards. When such products enter into international trade they may encounter difficulties because of differences in packaging and containerization practices in countries having different systems of measurement.

Manufacturing differs from construction in that the products of construction are assembled on site and are not usually transportable; therefore, they classification covers the entire field of economic activities: agriculture, forestry, and fisheries; mining; construction; manufacturing; transportation, communication, gas, electric and sanitary services; wholesale and retail trade; finance, insurance, and real estate; services; and government.

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[2] *Standard Industrial Classification Manual*, Bureau of the Budget, Office of Statistical Standards, 1967, p. 37.

Each of these major divisions is further broken down into major groups and subgroups, and individual industries to which numbers are assigned for reference. Major groups are assigned 2-digit numbers, subgroups within each major group are designated by adding a third digit, and within each subgroup individual industries are designated by adding a fourth digit. Thus, for example, major group 37 in manufacturing covers transportation equipment and subgroup 372 includes aircraft and parts. Industry 3721 pertains to the manufacture of aircraft, 3722 includes aircraft engines and engine parts, 3723 covers aircraft propellers and propeller parts, and 3729 is comprised of aircraft parts and auxiliary equipment (not elsewhere classified). The specified numbers corresponding to certain groups, subgroups, and individual industries are often referred to as SIC codes. The manufacturing division (D) comprises 21 major groups and over 400 4-digit industries. The number of 4-digit industries included in the manufacturing division is approximately equal to the number of 4-digit industries included in all of the other industrial divisions.

b. Use of the SIC Codes for the Survey. Although the Standard Industrial Classification was not devised as a means for studying the effect of metrication on industries, it serves the purposes of the study very well for several reasons:

(1) It serves as a guide to completeness of coverage of the manufacturing sector.

(2) It provides a basis, with standard terminology, for defining a group of products for which a company can be requested to report on progress and implications of metrication.

(3) It supplies a grouping of industries according to a certain commonality of operation that might be expected to correlate with the impact of metrication.

Many 4-digit coded industries could have identical problems in the process of metrication, but on the other hand, even within a specific 4-digit industry, the problems of metrication might be very different depending on the particular products involved.

c. Use of Companies Rather than Establishments. There were about 312,000 establishments engaged in manufacturing in 1967. An establishment is generally defined as a plant at a single physical location engaged in only one or predominantly one type of activity for which an industry SIC code is applicable. Thus, an establishment is not necessarily identical with a business concern or company, which may consist of one or more establishments.

A company, in contrast to an establishment, is a business organization consisting of all establishments under common ownership or control, including a central administrative office and auxiliaries, if any, which may provide supporting services. Of the 312,000 manufacturers reported in the 1967 *Census of Manufactures*, about 275,000 were single-establishment compado not enter into international trade (although foreign construction by U.S. firms may involve other related manufactured products and funds in international trade). The materials used in the construction industry are almost entirely products of manufacturing. Thus, the problems that would arise in construction if the country were to increase metric usage would probably be comparable to those involved in manufacturing.

3. HISTORICAL CONCERN OF THE MANUFACTURING SECTOR

Companies engaged in manufacturing have been traditionally more concerned about any trend of the United States going toward increased use of the metric system than those in other divisions of the economy (based on reports of metrication's legislative history). The reasons for this concern are related to trade and cost implications. The manufacturing sector may have much to gain from a transition to metric usage by way of increased foreign trade, and may have much to lose through increase of imports from metric countries which could then compete more effectively with domestic-made products. Also, the cost of making the change in manufacturing is likely to be greater than that for nonmanufacturing industries, in proportion to the contribution of these industries to the gross national product.

A change to increasing metric usage in manufacturing essentially is what is called a "hard" change; that is, it would be necessary, in many cases, actually to change machinery, methods of manufacturing, engineering standards of articles, and the sizes and shapes of many products. Change cannot be accomplished in many cases by simply relabeling products or respecifying them in a different measurement language.

A growing concern with the metric problem has been evidenced by the various manufacturing industries over the past years, particularly during the last decade. This concern has resulted from the increased internationalization of many manufacturing activities. Many American-based companies are now manufacturing in other countries where the use of metric measures and metric standards is legally required or necessary for practical reasons. This has required many U.S. companies to resort to the practice of dual-dimensioning on their drawings; that is, indicating dimensions in both metric and customary (U.S. System) units so that the drawing can be utilized equally well in a metric or a U.S. shop, or with either metric-based or U.S.-based equipment in a shop. However, manufacturing difficulties are often experienced because stock sizes available in the United States do not always conform to stock sizes available in metric countries.

B. SURVEY BACKGROUND

1. USE OF THE STANDARD INDUSTRIAL CLASSIFICATION (SIC)

a. SIC Structure. Analytical studies of the economy of the United States frequently employ the Standard Industrial Classification published by the Office of Management and Budget (formerly Bureau of the Budget). This nies. The remaining establishments were in multi-establishment companies, and although the number of establishments in multi-establishment companies is relatively small, they account for a large fraction of total manufacturing production.

The decision was made to direct the manufacturing survey to companies rather than to individual establishments, but for a particular company the inquiries in the survey would relate only to the principal SIC product group of the company, or in some instances to one or more specified SIC product group of the company. This was considered a useful approach, since many of the questions could be more readily answered when related to a specified SIC product group, and would reflect the activities, policies, plans, and attitudes for companies as a whole with respect to the SIC product group. Those companies with more than one establishment would be surveyed on the basis of their principal SIC product code.

2. VISITS TO PLANTS

Many manufacturing establishments were visited by National Bureau of Standards personnel during the course of the study to ascertain the metrication problems that they would encounter both in the United States and abroad. These field studies were conducted by viewing the plant operations and through conversations with key personnel within the plants. Many of these visits occurred before the study was formally initiated, because of the existing close connection of National Bureau of Standards personnel with manufacturing processes and standards problems. Members of the Study Group are greatly indebted to the personnel of these establishments for their helpful advice and willing cooperation.

In many cases, in the judgment of the National Bureau of Standards personnel, there was a tendency by the visited company personnel to exaggerate the seriousness of the impact of metrication. This tendency seemed to be motivated by the apprehension that many companies have about "conversion" to the metric system, which is not the basis of this survey. The survey was concerned with current usage and with increased metric usage in most questions. Some questions were based on a set of assumptions that defined a specific type of increased metric usage (metrication) that might be termed "substantial conversion," but none was based on "total conversion" to the metric system. Many of the plant people assumed that expensive machines and equipment would have to be completely replaced in total to produce a product with metric specifications. They generally had not taken time to realize that the same result could be accomplished in many cases by simply changing a dial or using a conversion table for setting machines and equipment to the nearest customary measurement value to produce the metric product. In most cases, it was generally agreed by them that if metrication were a gradual process in accordance with the principles that have been set forth in the ANSI publication *Orientation for Company Metric Studies*[3] the cost of the change would not be as great as initially anticipated.

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[3] Available from American National Standards Institute, Inc., 1430 Broadway, New York, N.Y. 10018.

3. ALTERNATIVE SURVEY METHODS

Even before the enactment of the legislation that authorized the study, consideration was given to various means by which a survey could be performed for the manufacturing sector industries. An examination and analysis of these methods were undertaken by the National Bureau of Standards Metric Study Group. The major considerations and results from the analysis are presented below.

a. Individual Company Interviews. One of the survey methods that was contemplated was the use of individual interviews with various companies by members of the Metric Study Group. Such a face-to-face, in-depth technique would probably yield the most definite information about problems that have arisen in companies using the metric system and could lead to relatively accurate information, in many cases, of actual cost of metrication. However, an earlier experience from interviews with key personnel of some companies had shown that very few had any substantial knowledge of the problems that might be encountered in the process of metrication or the most effective solutions to these problems. The Study Group members would, therefore, have to be well versed in the problems of metrication to communicate clearly the guidelines that should be followed by the various manufacturing industries to explain the different techniques that could be used in minimizing possible costs of a transition and understanding the intent of the feedback they were receiving. Early in the study, it was decided by the Metric Study Group that it would be impractical to pursue this line of attack because of the limitations of time, money, and trained interviewers. Thus, the number of companies that could be reached via individual interviews would be too small because of these limitations and would therefore provide an inadequate sample, unless the resources made available for the study were very large.

b. Views of Industry Consultants. A second method that was considered was the employment of industry consultants who are specialists in the various industries to be surveyed. Such consultants would be engaged to make studies for the individual manufacturing sector industries in which they are specialists, by utilizing company interviews or other methods as needed. This method was also considered to be unsatisfactory by the National Bureau of Standards Study Group because, while the industry specialists who could be employed might be well versed in the problems associated with their industry apart from metrication, it is unlikely that many of them would be sufficiently well versed in the metric problem itself to make a meaningful survey. This might well contribute to a noncommonality of purpose and lead to a disparity in the point of view and data collected for the different industries. Furthermore, this technique, as well as the first interview technique using members of the Study Group, would not supply easily documented information.

c. Use of Mailed Questionnaire. The use of mailed questionnaires to obtain the necessary information for the study was considered a strong third possibility. This method had several obvious advantages.

(1) A much larger number of companies could be reached by this means, rather than by personal interview, for the same amount of resources.
(2) The data collected could be more standardized and therefore more readily adapted to statistical analysis and evaluation.
(3) The responses to the questionnaires would be a documented permanent record to substantiate the conclusions reached from the study.

The questionnaire approach, however, had two potential faults:

(1) The limited response that mailed questionnaires often receive, unless the reply is mandatory under the law (which in this case it was not since there was no provision in the metric study law that could be used to require a mandatory response to the questionnaire).
(2) The inadequacy of information on the part of the respondents regarding the metrication problem to which they would be addressing themselves.

It was believed, however, that the first of these faults could be remedied by a program of publicizing the questionnaire so that prospective respondents would realize the importance to their company of expressing their firm's views and supplying the questionnaire information requested by the Metric Study Group, and by providing for an intensive follow-up for a sample of the initial nonrespondents. The second weakness could be substantially overcome by adequate presentation to technical societies and trade associations of the problems of metrication and by the development and establishment of good guidelines and background material to be circulated prior to and with the questionnaire. Experience had shown that both of these remedies could be effective if properly administered.

4. DECISION TO USE MAILED QUESTIONNAIRE SURVEY METHOD

a. Influence of the ANSI Metric Advisory Committee. Another factor had a decided bearing on the survey method used. In the late summer of 1968, the American National Standards Institute (ANSI), which was at that time known as the United States of America Standards Institute, established a Metric Advisory Committee, by appointment of Francis K. McCune, President of the Institute. The purposes of this advisory committee were (1) to serve the members of ANSI, and (2) to cooperate with the United States Government in conducting the survey called for by the Metric Study Act.

Although there was much personal contact between the initial small staff of the Metric Study Group at the National Bureau of Standards and members of the ANSI Metric Advisory Committee, under the chairmanship of Louis F. Polk, there was no official connection between the two groups. The ANSI Metric Advisory Committee established a Subcommittee on Industry Studies under the chairmanship of William K. Burton.

The ANSI subcommittee, operating independently of the National Bureau of Standards Metric Study Group, established guidelines for companies making metric studies. On March 18, 1969, a meeting was arranged between the Metric Study Group staff at the National Bureau of Standards and members of the ANSI Subcommittee on Industry Studies. At that time, the first draft of the document prepared by the ANSI subcommittee for the guidance of companies making metric studies was presented. These guidelines are now included in the ANSI document *Orientation for Company Metric Studies.*

b. Selection of the Survey Method. An important aspect of the committee's operation was the assessment of the cost of transition of a company to the metric system of measurement and use of metric engineering standards.

The metrication cost viewpoints set forth in the preliminary document agreed so well with those independently developed by the Metric Study Group of the National Bureau of Standards that it was decided by the Group to adopt these views as the approach to the formulation of the questionnaire to determine costs of metrication. Moreover, the independent development by ANSI's Metric Advisory Committee of detailed procedures to be followed by respondents before answering the cost questions involved in metrication led the Metric Study Group to the firm decision to use a mailed questionnaire survey instrument directed to companies in the manufacturing sector for cost data collection. It was decided at the same time to utilize also a mailed questionnaire for the collection of general information.

5. ESTABLISHMENT OF GUIDELINES

If the responses to a mailed questionnaire were to be meaningful, clear guidelines would have to be established for the respondents. It would not be effective, as experience had shown previously, to go out to a group of prospective mail questionnaire respondents with various alternatives that might be followed in the process of metrication. Therefore, clear assumptions had to be stated. The most important of these assumptions was that metrication would take place only on new products or newly designed old products. Products already in production would not be changed, unless there were some special reasons for making a change. It seemed clear that any other course of metrication would make the process prohibitively expensive. At about the time that these conclusions had been reached, the Study Group was presented with the views established by the American National Standards Institute committee.

The orientation document prepared by the Subcommittee on Industry Studies of ANSI contained a very important guideline that was used in connection with all questionnaires submitted to prospective respondents. After discussing the problems, expense, and possible chaos that would result from various other assumptions, the guide recommends that we "assume that only new uniquely designed major components or end products requiring new special tooling would be specified in metric modules only after new metric standard parts and materials are available at reasonable cost. This could be accomplished on an optimum schedule as present product designs become obsolete on a timetable compatible with marketplace requirements and normal tool obsolescence. Such a plan would result in minimal costs as new unique major components are designed in metric modules. Interface considerations must be given to mating carry-over components."

This assumption implicitly indicates that, if there is to be a change in the use of units from our customary system to the metric system, it will be on a coordinated basis. Also, the assumption implies that if and where the manufacturing industry increases its metric usage, it will be a "hard" change; that is, we will change not merely to metric measurement units but also to metric-based standards in most cases, unless existing United States standards are in extensive use throughout the world.

It was recognized that the use of these guidelines in conducting the manufacturing industry survey would yield cost estimates that would be greater than if one were to elect a "soft" change in the manufacturing sector industries. However, it is recognized that, in many cases, a "hard" change would not be necessary to realize all the benefits that might accrue from necessary increased metric usage.

C. DESIGN OF QUESTIONNAIRES—FORM A AND FORM B

Since it was also necessary to obtain information on questions of general interest, such as the present status of metric usage in the United States, its rate of increase, and the attitude of industry toward metrication, as well as on the cost involved in undertaking to increase metric usage to the greatest feasible extent, a decision was reached by the Metric Study Group to use two separate questionnaires. One, designated part A, had to do with general information; and the other, designated as part B, had to do only with the assessment of costs. All prospective respondents were requested to reply to part A, but part B was to be completed by only those who were willing to undertake the in-depth studies that were necessary to assess costs realistically.

1. DESIGN OF PART A FORM

Part A, in addition to requesting information regarding company size, sought information on the present usage of metric units or metric engineering standards in the principal SIC product group of the company. From those not using metric units or engineering standards for the principal SIC product group no further information was solicited regarding their experience, but from those who are presently or have been using metric units or engineering standards for the principal SIC product group, various questions were asked regarding the reasons for such usage and advantages and disadvantages that had been experienced in various areas. Companies not now using metric measurement units, or metric engineering standards, were asked questions regarding their independent plans for such usage, regardless of what course the country as a whole might follow. Questions were also asked of these companies regarding their foreign operations and export trade. Following these questions a series of questions was submitted on form A in which the respondents were asked to assume that there would be a coordinated national program of metrication based on voluntary participation. Respondents were asked to state the advantages and disadvantages that they anticipated for their firms from such a program. These respondents were also asked to give their estimates of the effect of increased metric usage on the company's domestic and foreign sales and, particularly, the effect of imported metric products, if a national program of metrication were to be applied in the United States.

Finally, a series of questions was included to elicit information from the particular company responding about its attitude on the use of the metric system and metric standards within their company, and to elicit the views of that particular company on whether metric usage is in the best interests of the United States. Each respondent was asked to give his opinion as to whether a national program of metrication based on voluntary participation, a mandatory program based on legislation, or no national program at all should be followed if increased metric usage is found to be in the best interests of the United States. At the end of the questionnaire respondents were invited to submit general comments on the subject of metric usage. For more complete details about the questionnaire, refer to appendix B.

2. DESIGN OF PART B FORM

Part B, which is simpler in appearance than part A, nevertheless involves much more preparation and analysis on the part of the respondents. (Refer to app. B for the complete questionnaire.) There are two sections to part B: section 1, which is designed for those supplying end products, and section 2, which is designed for those supplying standard parts or standard materials. Respondents were assured that data supplied would be used and published in such a way that proprietary information would not be revealed. Information on the magnitude of sales was requested within wide dollar ranges. Data on added cost due to metrication were requested as a percentage of the total value of sales of the SIC product group over the company's optimum transition period. Respondents were asked to report the percentage of total value of purchased materials and parts in proportion to sales. Other data solicited were the optimum transition period for the primary SIC product group being reported on; and the distribution of this cost among personnel education, engineering and research and associated documentation, manufacturing and quality control, records and accounting, standards association activities, warehousing, sales and services, and other items. Respondents were asked to estimate how a transition over a 10-year period would affect the estimate they had made based on the optimum transition period. Also, they were asked to indicate whether significant tangible savings would result from the transition to the metric system for their primary SIC product group and if so, the length of time that might be involved in recovering the cost of the change. Section 2 contained a few deviations from this procedure, since suppliers of standard parts and materials cannot, of themselves, determine what course of action their companies would follow, being guided entirely by customer demands. They were asked to respond to the in-house added cost for maintaining dual capability in supplying standard parts and materials and the cost of maintaining this dual capability on an annual basis.

3. CONSULTATION WITH INDUSTRY REPRESENTATIVES

Throughout the development of both parts A and B of the questionnaire, extensive reviews and consultations were conducted with industry representatives, particularly members of the ANSI Metric Advisory Committee. Many useful suggestions were received from these individuals, particularly in connection with placing the questions in a logical format and structure for answering and in such a manner that the responses could be meaningfully tabulated.

4. OFFICE OF MANAGEMENT AND BUDGET ADVISORY PANEL

Since a questionnaire circulated by an agency of the Federal Government requires approval from the Office of Management and Budget (OMB), advice and guidance were sought from representatives of this agency before the questionnaire was put into its final form. The OMB established an advisory panel that included many individuals who had been instrumental in the original development of the material, to review the questionnaire.

A version of the questionnaire forms, parts A and B, was submitted to the OMB on February 11, 1970, and the first meeting of the advisory panel on the questionnaire was called for March 12, 1970. Final approval of the questionnaire was obtained on April 28, 1970. There is no doubt that the services of the advisory panel on the questionnaire greatly improved its contents.

5. PARTICIPATION BY WESTAT RESEARCH, INC.

In June 1970 the Metric Study Group decided that steps should be taken to insure that data that would be forthcoming from the questionnaires would be expertly and objectively interpreted, analyzed, and documented. A search was then made to find the individual or firm qualified to perform this task. The search led to Mr. Morris H. Hansen, Senior Staff Advisor of Westat Research, Inc., who was formerly Associate Director for Research and Development at the U.S. Bureau of the Census and who was the senior author of the two volume internationally recognized publication *Sample Survey Methods and Theory.* Accordingly, Westat Research, Inc. was brought into the study to assist in the design of the remaining phases of the study, the final data collecting, data processing, statistical analysis, and interpretation of the survey results.

D. DESIGN OF SAMPLES FOR FORMS A AND B

Since responses to the part B questionnaire (form B) required considerable work on the part of the respondents, a decision was reached by the Metric Study Group that it would not be feasible to obtain effective cooperation, and therefore valid information, from a random or "probability" sample of individual companies in the various manufacturing industries. On the other hand, the information required for part A was less burdensome, and it would be feasible to obtain information from a broad sample of companies. Consequently, a decision was made to use a probability sample for form A, distributed among all industries to be covered by the survey. Different sampling procedures were therefore decided upon for prospective respondents to part A and part B, although all respondents to part B were also requested to respond to part A. Respondents to part A were invited to respond to part B if they so desired, but were requested to seek additional background information from the Metric Study Group if they chose to make a response to part B.

1. SELECTED SIC CATEGORIES I, II, AND III

All of the 4-digit SIC product codes covered by the 2-digit codes 19 through 39 (manufacturing) were examined and assigned to one of three categories (I, II, or III) according to a judgment as to the expected commonality and nature of the problems involved in metrication for companies with that primary SIC code and the nature of the product. These three categories, referred to as the *original* SIC categories, were used for defining the universe of manufacturing companies to be covered by the survey and for sample selection purposes. The 4-digit codes included in each category are in appendix C. More generally, the SIC categories can be described as follows:

CATEGORY I:

Companies producing assembled manufactured products such as automobiles, aircraft, appliances, and other machinery and equipment.

CATEGORY II:

Companies producing other measurement-sensitive products such as steel and other rolling mill products, metal cans, bearings, fasteners, screw machine products, paper and lumber.

CATEGORY III:

Companies producing products that are less measurement-sensitive. Examples are cutlery, rubber, leather, furniture, jewelry.

These categories are referred to as the original SIC categories because some revisions were made in the assignment of SIC codes to the categories for purposes of tabulation and analysis. The revised SIC categories are referred to as SIC categories A, B, and C to avoid confusion. However, the above general category descriptions are still valid for the three categories A, B, and C. The tabulations, analysis, and conclusions in chapters II and III are based on categories A, B, and C. (App. C. gives a complete listing of the SIC codes within the three original and three modified categories.)

2. DESIGN OF SAMPLE FOR PART A

a. Dun & Bradstreet Listing. The Department of Commerce has an up-to-date Dun & Bradstreet magnetic tape file of companies engaged primarily in manufacturing, including about 300,000 individual companies. Because this file presumably covered most companies with manufacturing as their primary activity, and included information on the principal SIC product code and on the employment size of most of the companies in the file, it would provide an adequate and convenient source for selecting the sample. Consequently, it was decided to select the sample from those companies included in this magnetic tape file. The use of this file also facilitated the preparation of address labels and information regarding the company size, industry involvement (i.e., SIC code) and other material necessary to control the issuance and return of the questionnaire forms.

b. Definition of Universe to be Covered by Part A Survey. The universe of manufacturing companies represented by the part A survey consists of all manufacturing companies with 50 or more employees (as classified by Dun & Bradstreet) plus those companies in SIC category I (as defined in D.1) with less than 50 employees.

About 80 percent of the manufacturing companies in the United States are small companies (with less than 50 employees) in the SIC categories II and III as defined above. These companies account for only about 15 percent of the total manufacturing output, and it appeared that most of them would not be as highly impacted as SIC category I companies, and would not have as much information on the implications of a metrication program. Consequently, for the 1-49 size class a decision was made to exclude companies in SIC categories II and III from the survey and to compensate for this exclusion by increasing the sample size of SIC category I.

c. Selection of the Sample. The employee size classes used in the sampling stratification were 1 to 49, 50 to 499, 500 to 2,499, and 2,500 and over. The original intent was to have a sample size of approximately 300 for each employee size class within each original SIC category. It was found, however, that for the larger companies (2,500 employees and over) the number of companies in each SIC category-size cell was, in general, less than 300, and for these cells all companies were included in the sample.

In order to provide information separately by employment size class and by the SIC categories, the sample was allocated to the employee size classes and original SIC categories as shown in the following comparison of the universe and sample size for each SIC category-size cell:

Original employment size class	Original SIC category	Universe	Sample
1–49	I	19,355	967
50–499	I	3,515	351
	II	7,762	388
	III	21,904	365
500–2,499	I	323	323
	II	515	515
	III	1,304	326
2,500 and up	I	139	139
	II	181	181
	III	283	283
Total		55,281	3,838

The sample of companies was selected from the Dun & Bradstreet file by taking a systematic sample (i.e., every k^{th} item in the list), with the sampling intervals (the values of k) chosen to produce the desired sample size in each cell.

The sample for the 1-49 employee size class (limited to SIC category I) was larger than the other samples because a lower initial response rate was expected from the smaller companies, and so that the total sample of companies with fewer than 500 employees would be approximately the same size (2,071 companies) as the total sample of those with 500 or more employees (1,767 companies).

d. Response to Two Initial Mailings. A first mailing to the 3,838 companies in the sample was made on May 28, 1970. A second mailing to those not responding to the first mailing was made on July 10, 1970. A total response of 1,859 companies was received, leaving a total of 1,979 initial nonrespondents after the two initial requests by mail.

e. Sample of Nonrespondents. A subsample of approximately 350 companies was drawn from the 1,979 initial nonrespondents for intensive follow-up by certified letter and telephone. On the basis of the initial respondents and the results of the intensive follow-up of the subsample of nonrespondents, the calculated over-all effective response rate was 84 percent.

f. Detailed Description of Sample Selection, Estimation and Variances. A detailed description of the sample design and procedure, response rates, estimation, and estimation of variances is given in appendix A.

3. DESIGN OF SAMPLE FOR PART B

While the sample for part A could be very broadly based, it was necessary that the sample for part B be confined to those companies with enough interest in the problem of metrication to be willing to do the background work necessary to provide considered responses to the difficult cost questions on form B. For this reason it was decided to solicit responses from those companies in which responsible individuals would agree to carry out the necessary studies to assess the cost of a change in the measurement system and a change in the standards utilized in their operations. Contacts were made with individuals of these companies, often through trade associations, and they were asked to take a personal interest in their company's response to part B.

The companies included in this survey for part B responses are biased in the sense that these companies have had some experience or concern, in most cases, in the process of metrication because of international operations or because of demands placed upon them in the home markets. An assessment of the sample appears in appendix A, where it is seen that the sample includes companies that have been opposed to a change in our measurement system, as well as companies that favor a change and others that have a neutral position.

While many of the respondents to part B were solicited from large companies, the Study Group was particularly fortunate in obtaining many responses on the form B cost questionnaire from small business through the Small Business Association, of which Mr. Carl Beck is President. Most of these companies are not completely independent in their operations. It is their job to supply the needs of various large manufacturers in special areas, so that if a determination is made by a large manufacturer to require a metric-designed part, these smaller companies must take into account the requirements of their larger-sized customers.

Appendix A contains a description of a small supplemental probability sample that was drawn, and on which cooperation was solicited from the firms involved, and describes the results obtained. It also contains a detailed description of the procedures followed for the part B sample and the preparation of estimates. The part B survey is also discussed in chapter II.F (Cost and Time Implications) of this report.

II. DETAILED FINDINGS AND ANALYSES

As indicated in the previous chapter, the metric survey of manufacturing companies consisted of two parts described as follows:

(1) Part A – A mail survey sample of about 3,800 companies chosen from a specified universe of about 55,000 manufacturing companies. The survey instrument was a questionnaire consisting of some 21 questions dealing with metric usage and company attitudes toward the metric system and a national program of metrication.

(2) Part B – A survey of a much smaller sample of manufacturing companies to determine metrication timing and cost under a coordinated national program of metrication based on voluntary participation.

In the part A survey, manufacturing companies were classified into four classes by number of employees (employee size class) and into three groups by type of manufacturing industry (SIC category). (A full description of sample selection, estimation, and variance calculation procedures is given in app. A, of the questionnaires and transmittal letters is given in app. B, and of the original and revised SIC categories is given in app. C.)

The data collected in the survey, in addition to company identification and product description, included:

(1) employment and sales size class,

(2) a number of questions concerning actual and anticipated use and impact of the metric system with no coordinated national metrication program.

(3) a number of questions asking for views on the use and impact of the metric system assuming a coordinated national program of metrication based on voluntary participation,

(4) a series of questions about the attitudes and opinions of manufacturers concerning increased use of the metric system.

The replies have been tabulated for each question to provide estimates, expanded to represent all companies that would have responded had the survey not been conducted on a sample basis, of (1) the number and percent of companies giving various responses, and (2) the number and percent of employees of manufacturing companies giving the various replies. In the latter case, the estimates were weighted by number of employees as a means of roughly reflecting the value added to the nation's economy through manufacture by the companies. In a few instances, tables were prepared showing averages of reported percentages. Each of these estimates has been further subclassified by SIC category and by employment size class. The detailed tabulations are given in appendix E-II for every part A survey question and some cross-tabulations of sets of questions.

The data collected in the survey on form A relate to the principal SIC product group of a responding company. The principal SIC product group is that group of products covered by the Bureau of the Budget's Standard Industrial Classification 4-digit code system for manufacturing industries. All of the products of some companies are covered by a single SIC product group. However, some companies have diversified production, and their total activities may involve several or many SIC product groups. In the text of this report the discussion is generally presented as though the data summarized relate to the total activities of the company, without being careful in each instance to specify that the responses relate only to the principal SIC product group of the company. This is done to simplify the presentation. The reader should be aware that the presentations and conclusions do relate only to the principal SIC product group of a company in each case. It is not clear how the results would differ, if at all, if each company had been requested to report separately on each of its SIC product groups, and the results then aggregated. It seems reasonable to assume that the results obtained would not have been importantly different from those obtained for the principal product groups of the reporting companies.

The company employment figures actually used were based on the responses to question 1 on form A, with the following assignments made for the respective employment class interval responses (based on some rough knowledge, from other sources, of the nature of the distribution of employment within the employment classes).

Employment class interval as reported:	*Average value assigned for number of employees*
1–49	10
50–249	100
250–499	350
500–999	700
1,000–2,499	1,600
2,500–10,000	4,800
Over 10,000	30,000

These employment figures are, of necessity, very rough. The figures derived from them have been reported in the tables as "number of employees" or "employment." They are adequate only as rough measures of employee size. The assignment of particular values within the class intervals is not critical in terms of the effect on the interpretation of the results.

The following table (table II-1) shows (col. 2) the distribution of companies in the universe from which the initial sample was selected by size class, using employment size class as reported in the Dun & Bradstreet lists. The table also shows (col. 3) the estimated number of companies represented by the returned form A's, obtained by weighting these returns by the weights used in making the company tabulations. The weights were the reciprocals of the over-all sampling fractions. The differences represent primarily the nonrespondents after the full follow-up efforts. The differences also reflect to some extent the consequences of respondents' reporting on form A a different number of employees for their company than the number provided from the Dun & Bradstreet files. No imputation or expansion was done to represent the nonrespondents – in this or other tables. The companies represented in the tabulations are, in effect, those 46,480 companies that would have responded had form A been mailed to all companies on the universe list and if the intensive follow-up had been carried through for all nonrespondents.

Table II–1. Universe distribution by employment size class

Employment size class	Number of companies in universe from which sample was selected	Number of companies and employment represented in returned form A's[1]	
		Number of companies	Number of employees (1000's)
1–49	19,355	18,961	190
50–499	33,181	24,861	3,274
500–2,499	2,142	2,138	2,241
2,500+	603	520	5,736
All companies	55,281	46,480	11,441

[1] Weighted to universe level, but excluding nonrespondents after intensive follow-up, and inferred from employment class reported on form A response.

Table II-2 shows the total number of companies in original SIC categories I, II, and III in the universe from which the sample was selected, compared with the estimated number of companies in the universe of respondents to the survey (weighted as in table II-1) in the revised SIC categories A, B, and C. The number of employees (in 1000's) is also shown for the revised categories.

Table II-2. Universe distribution by SIC category

General description of category (applied to original or revised)	Original SIC categories		Revised SIC categories		
	Symbol	Number of companies	Symbol	Number of companies	Number of employees (1000's)
Selected finished machinery and equipment	I	23,332	A	11,581	2,290
Selected components, instruments, and dimension materials	II	8,458	B	16,087	4,031
Other	III	23,491	C	18,812	5,120
Totals		[1] 55,281		[1] 46,480	11,441

[1] As shown in table II-1.

Even though the form A responses on metrication relate to the principal product group of a company, tabulations based on number of employees were made by weighting the reported approximate employment figure for the entire company rather than for the SIC product group. Employment or value added by manufacture for the SIC product group would have been used as the weight had the needed information been available. For lack of such specific product group information, approximate total company employment was used as a substitute. Again, it is not clear how much difference this makes, but it seems reasonable to assume that averages of percentages weighted by using the total company employment will be at least rough approximations to what would have resulted if the weights could have been based on the company employment associated with the principal SIC product group.

For more specific information on the preparation of estimates from the survey results, the reader is referred to appendix A, on sample selection, estimation and variances.

The format of the remainder of this chapter follows roughly the format of the form A questionnaire, which is given in appendix B. Reference is made, where appropriate, to the specific question number on form A and the corresponding specific tables found in appendix E-II, that give the detailed tabulations and cross-tabulations for information discussed in the text (e.g., ques. 5, app. E-II, table 1).

A. CURRENT AND ANTICIPATED USE OF THE METRIC SYSTEM BY U.S. MANUFACTURING COMPANIES ASSUMING NO COORDINATED NATIONAL PROGRAM OF METRICATION—PART A SURVEY

1. COMPANIES NOW USING METRIC MEASUREMENT UNITS AND/OR ENGINEERING STANDARDS TO SOME EXTENT

a. Metric Use in Any of the Specified Activities (ques. 5, app. E-II, table 1).[1] In 1970 more than 10 percent of the companies represented in the general metric study of manufacturing companies in the United States were users of metric measurement units and/or engineering standards for at least part of their activities. The estimated number of companies that use metric measurement units and/or metric engineering standards to some extent and total number of employees represented by these companies are given in table II-3 and figure 1 by employee size class and SIC category. (In the following discussion these companies will be referred to as "companies using the metric system.")

Table II-3. Estimated number of companies and employment of companies that use metric measurement units and/or engineering standards by employment size class and SIC category

	Number by size class and SIC category		Percent usage by size class and SIC category	
	Companies	Employment (thousands)	Companies	Employment
Total	5,324	3,198	11	28
By employment size class:				
1–49	1,569	16	8	8
50–499	3,074	510	12	16
500–2,499	521	552	24	25
2,500+	160	2,120	31	37
By SIC category:				
A. Selected finished machinery and equipment.	1,386	684	12	30
B. Selected components, instruments, and dimension materials.	1,463	1,019	9	25
C. Other	2,475	1,495	13	29

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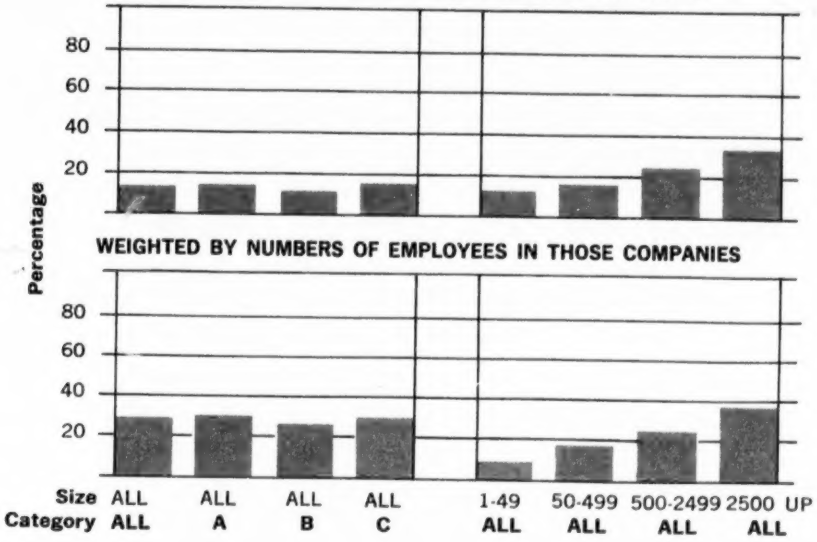
[1] Note: Similar references appear throughout the remainder of the text discussion. All the detailed tabulations are provided in app. E-II. The questionnaires are given in app. B.

FIGURE 1

COMPANIES USING SOME METRIC UNITS OR STANDARDS



It is noted that the percent of companies within an employee size class using the metric system increases substantially as company employment size increases (from 8% for size class 1-49 to 31% for size class 2,500+). Also, the percent of employment represented by companies using the metric system increases at nearly the same rate (from 8% for size class 1-49 to 37% for size class 2,500+). The number of companies using the metric system is substantially greater for small companies than for large companies. However, the total number of employees represented by companies that use the metric system is found to be fewer for small companies (16,000 in the 1-49 size class) and much greater for large companies (2,120,000 in the 2,500+ size class).

The companies that use the metric system represent more than one-fourth (28%) of manufacturing activity in terms of employment. Thus, if the employment measure does reasonably represent value added by manufacture, then the present metric usage is of greater importance than that indicated solely by number of companies.

The percent of companies using the metric system does not vary widely among SIC categories (A-12%, B-9%, C-13%), the differences among these being small relative to the sampling error involved as shown in table II-14. Percent of employment represented by companies using the metric system is also about equal among SIC categories (A-30%, B-25%, C-29%). It should be noted that the latter employment-weighted percentages are much higher than the company-weighted percentages for all SIC categories.

b. Metric Use in Specified Activities (ques. 5a, app. E-II, tables 2-6). Metric users were asked to estimate the approximate percentage use for five company activities for the years 1965, 1970 and 1975. The 1970 usage by these activities is given in table II-4. The data tabulated in tables II-4, II-5, and II-6 are for 1970.

Table II–4. Estimated number of companies and employment of companies that use metric measurement units and/or engineering standards by five specified activities in 1970.[1]

Activity	User companies		Employees of user companies	
	Number of user companies for activity	Percent of all metric user companies	Number of user company employees for activity (thousands)	Percent of employment of all metric user companies
(1) Design, engineering, shop drawings	2,124	40	1,428	45
(2) Catalogues	921	17	926	29
(3) Research and development	2,963	56	2,554	80
(4) Manufacturing process	3,102	58	1,700	53
(5) Labeling	1,137	21	1,056	33
(6) Other	504	9	314	10

[1] Tables by size class and SIC category are given in table II–5 and also in app. E–II, table b 2.

The metric users reported metric usage, on the average, in two of the five specified activities.

More than half of the companies using any metric measurements or standards in 1970 used them in manufacturing processes, including tooling and test equipment (58% of metric user companies) and in research and development (56% of metric user companies). Companies using metric measurements in manufacturing processes also accounted for slightly over half of the employment of all metric users (53%). In the case of research and development, however, very large firms were predominantly metric users so that companies using metric measurements in research and development had 80 percent of the employment of all metric users. Forty percent of the metric user companies used metric measurements in design, engineering, and shop drawings. A smaller proportion of firms used metric measurement units and/or engineering standards in labeling (21%) and cataloguing (17%).

Table II-5 shows prevalence of metric usage for the various activities by employment size class, and by SIC category. The percentages in the table show the number (or employees) of metric users for the specified activity as a percent of all companies (or employees of companies) in the size class or SIC category that have any metric usage. The detailed tabulations are given in table b 2 of appendix E-II.

Table II-5. Estimated percentage of companies and employment of those companies that use metric measurement units and/or metric engineering standards in specified activities in 1970 by size class and SIC category. (The percentages reported relate to the total number and employment of companies having any metric usage.)

	Activity											
	Design, engineering, etc.		Catalogues		R&D		Mfg. process, etc.		Labeling		Other	
	[1]1	[2]2	[1]1	[2]2	[1]1	[2]2	[1]1	[2]2	[1]1	[2]2	[1]1	[2]2
Total	40	45	17	29	56	80	58	53	21	33	9	10
By employment size class:												
1–49	62	62	19	19	73	73	43	43	21	21	17	17
50–499	27	25	13	13	43	55	65	48	19	21	2	1
500–2,499	45	55	30	28	70	72	68	72	29	26	33	39
2,500+	52	46	38	33	80	88	51	50	39	38	5	4
By SIC category:												
A. Selected finished machinery and equipment	59	58	25	31	63	84	39	41	19	24	22	7
B. Selected components, instruments and dimension materials	57	4[illegible]	21	30	74	88	39	48	14	15	2	5
C. Other	19	39	11	27	41	72	80	62	27	50	7	15

[1] Percent of total number of companies that are metric users.

[2] Percent of total employment of metric users.

NOTE.—These percentages will typically understate the number of companies and associated employment of metric use relative to the potential for metric use. For example, let us assume that only 3,000 of the 5,324 metric users in 1970 have any catalogues—customary or metric. For 1970, 921 companies reported metric use in catalogues and the percentage reported is 17 (921 ÷ 5,324). Had 921 been divided by the number actually using catalogues (3,000) the percentage would have been 31.

See app. E-II, table b2 for detailed tabulations.

Large companies used metric measurements to a somewhat greater extent than did small firms in both labeling and cataloguing. There is no apparent consistent relationship between size of company and the use of metric measurements in design, engineering, and shop drawings; research and development; and in manufacturing processes.

Companies in the finished machinery and equipment industries (A) and those producing components and dimension materials (B) used metric measurements to a greater extent in design, engineering, and shop drawings; cataloguing; and research and development than did other companies (C). Companies in "all other" industries (C), on the other hand, used metric measurements in manufacturing processes and in labeling relatively more than did those in the dimensionally-sensitive industries.

Actually, the sampling errors are quite large for the comparison of type of use by metric users within size class or within SIC category, except that any results presented for the 2,500+ employment size class are relatively precise.

The previous paragraphs have related to the number of companies (and their associated employment) that used metric measurement units in specified activities. The statements following relate to the extent of metric use within the specified activity by those companies that reported metric usage greater than or equal to zero for 1970 in that same specified activity. For example, companies were requested to report the percentage of their catalogues using metric measurements to the total of all their catalogues. The figures referred to are averages of these percentages. Table II-6 gives these percentages, and table a 3 in appendix E-II gives the detailed tabulations. Average percentage of use was greatest for manufacturing processes (30), research and development (26) and labeling (20); and less for design, engineering, and shop drawings (15), catalogues (13), and other (9).

Table II–6. Estimated percentage of use of metric measurement units and/or metric engineering standards in specified activities in 1970 by size class and SIC category. (Percentages refer to the average percentage reported by those companies that reported metric usage greater than or equal to zero in 1970 for that activity.)

	Activity					
	Design, engineering, etc.	Catalogues	R&D	Mfg. process, etc.	Labeling	Other
Total	14	13	26	30	20	9
By employment size class:						
1–49	19	9	20	32	6	7
50–499	9	11	29	33	27	17
500–2,499	9	25	35	23	25	10
2,500+	7	18	35	11	23	7
By SIC category:						
A. Selected finished machinery and equipment	18	11	16	16	6	12
B. Selected components, instruments, and dimension materials	16	5	19	20	3	6
C. Other	6	19	45	38	34	7

See app. E–II, table a 3, for the detailed tabulations.

The patterns by SIC categories and size classes were quite diverse with respect to extent of metric use within the specified activities. Average percentage of use appears to be relatively insensitive to company size since little indication of any trend by size class is apparent. The highest percentage of metric use within an activity was by the larger companies in the research and development activity (35%). Companies in the finished machinery and equipment industries (A) reported the highest average percentages of metric usage for the design, engineering, and shop drawings activity (18%); research and development (16%); and manufacturing processes (16%). Those companies producing components, instruments, and dimension materials (B) also had the highest average percentage of metric usage in the same three activities (16, 19, and 20%, respectively). However, companies in SIC category C (industries whose products were dimensionally less sensitive) were highest in metric usage percentages for research and development (45%), manufacturing processes (38%) and labeling (34%).

An important indication of future changes in amount of metric usage by type of activity is the recent trend in the amount of metric usage by companies who were metric users in 1970. This trend is exemplified by the number of firms who were metric users in 1970 that responded with increased (or decreased) amount of metric usage from 1965 to 1970 and the number of firms that predict increased (or decreased) amount of usage from 1970 to 1975. One difficulty of interpretation of responses on amount of usage in question 5a of form A is that some firms indicated past or future usage as zero and others left the question blank. Estimates of increased and decreased metric usage (by more than 2%) by activity are given in table II-7 for companies indicating a usage greater than zero percent in 1970 for that activity and who also reported a usage greater than or equal to zero percent in 1965.

The number of companies that have an increase in metric usage from 1965 to 1970 is, in general, much greater than the number of companies having a decrease in usage in all activities except labeling. The largest absolute increases are in design, engineering, shop drawings; research and development activities; and manufacturing processes. In these activities, the companies reporting increases are 38, 22, and 20 percent of the companies that were metric users in 1965. The companies reporting increases include some nonusers as well as users in 1965. The largest decreases occurred in labeling activities, research and development, and manufacturing processes. In these activities, the companies reporting decreases are 27, 9 and 8 percent of the companies that were users in 1965.

Estimates are given in table II-8 for trends predicted for the 1970 to 1975 period. The number of companies predicting increased usage from 1970 to 1975 is greater in all activities than the number of companies that estimated increased usage from 1965 to 1970. In some activities (cataloguing, research and development, labeling) the number of firms predicting increased metric usage in the 1970-1975 period is nearly double the number having increased metric usage in the 1965-1970 period, even though the number in the base reporting period is somewhat lower for table II-7 (1965-1970) than for table II-8 (1970-1975). On the other hand, the number of companies predicting

Table II–7. Estimated number and percent of companies that have increased and decreased metric usage (by more than 2%) from 1965 to 1970 by type of activity (ques. 5a, app. E–II, tables b 2 and 5)

(1) Design, engineering, and shop drawings:		(4) Manufacturing process:	
Total users 1965	[1] 1,612	Total users 1965	2,532
Increase	607	Increase	502
	38%		20%
Decrease	51	Decrease	230
	3%		9%
(2) Catalogues:		(5) Labeling:	
Total users 1965	775	Total users 1965	1,036
Increase	262	Increase	285
	34%		28%
Decrease	1	Decrease	275
	–%		27%
(3) Research and development:		(6) Other:	
Total users 1965	2,636	Total users 1965	356
Increase	569	Increase	116
	22%		33%
Decrease	215	Decrease	0
	8%		0%

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[1] Total number of companies in each activity differs from tables II–4 and II–8 because some companies reported metric use greater than zero percent in an activity for 1970 but did not so report for 1965.

Table II–8. Estimated number and percent of companies that predict increases and decreases in metric usage (by more than 2%) from 1970 to 1975 by type of activity (ques. 5a, app. E–II, tables b 2 and 6)

(1) Design, engineering and shop drawings:		(4) Manufacturing process:	
Total users 1970	2,124	Total users 1970	3,102
Increase	719	Increase	758
	34%		24%
Decrease	0	Decrease	0
	0%		0%
(2) Catalogues:		(5) Labeling:	
Total users 1970	921	Total users 1970	1,137
Increase	486	Increase	479
	53%		42%
Decrease	0	Decrease	0
	0%		0%
(3) Research and development:		(6) Other:	
Total users 1970	2,963	Total users 1970	504
Increase	1,138	Increase	159
	38%		32%
Decrease	0	Decrease	0
	0%		0%

decreased usage in the 1970-1975 period appears to be negligible in all activities and equal to or less than the number of companies that estimated decreased usage from 1965 to 1970. No companies in the sample predicted decreased metric usage during the 1970-1975 period in labeling, even though the only large decrease in 1965-1970 was in labeling.

The companies that reported that they were metric users in 1970 were asked to report their actual and anticipated percentage of metric use in each of the activities discussed above for each of the years 1965, 1970, and 1975. The average percentage estimates by each year and activity were based on those 1970 metric using companies reporting metric usage greater than or equal to zero in that activity in that year. These estimates are given in table II-9. The trend for the 1965-1975 period in average percent usage within companies appears to be in the direction of slightly increased metric usage within all activities.

Table II–9. Estimated percentage of use of metric measurement units and/or metric engineering standards in specified activities in 1965, 1970, and 1975. (Percentages refer to the average percentage reported by 1970 metric using companies that reported metric usage greater than or equal to zero in the given year for that activity)(ques. 5a, app. E–II, table a 3)

Activity	Years		
	1965	1970	1975
(1) Design, engineering, and shop drawings	11	14	17
(2) Catalogues	12	13	17
(3) Research and development	24	26	34
(4) Manufacturing process, etc	30	30	34
(5) Labeling	20	20	24
(6) Other	7	9	No data

c. Metric Measurement Usage in Shop Drawings (ques. 5b, app. E-II, table 7). The metric users were asked the following questions concerning shop drawings:

> "If you are presently using metric measurement units in any of your shop drawings,
> (1) Do you use metric dimensions exclusively?
> (2) Do you use dual dimensions?
> (3) Do you use both metric and customary drawings?"

About 1,500 companies (with approximately 1,300,000 employees) use metric measurement units in their shop drawings. Only about 5 percent of these companies (with about 8% of their employment) use metric dimensions exclusively. Nearly 80 percent of these companies (with 65% of their employment) use dual dimensions, while about 60 percent (with about 75% of their employment) use both metric and customary drawings. Thus, a significant number of companies use dual dimensions as well as both metric and customary shop drawings.

d. Advantages and Disadvantages of Metric Usage (ques. 5c and 5d, app. E-II, table 10). Companies now using metric measurement units were asked to report for each of eleven specified areas whether or not they had experienced advantages in their metric usage and, for a similar but somewhat different list of eleven specified areas, whether they had experienced disadvantages.

Tables II-10a and II-10b show the results (of ques. 5c and 5d) for specific types of advantages and disadvantages, respectively.

Simplified specifications, cataloguing and records; and improved intra-company liaison and records were considered as notable advantages of metric usage, especially by the larger companies. Training of personnel under

Table II–10a. Specified advantages for companies that use metric measurement units and/or engineering standards (ques. 5c, app. E–II, table 8)

Specified advantage	Response of metric users to question on advantages experienced in use of metric measurement or engineering standards in 11 specified areas					
	Percent of total metric users			Percent of total employment of metric users		
	Yes	No	Don't know and no answer	Yes	No	Don't know and no answer
1. Training personnel	7	32	61	14	55	31
2. Economy in engineering design and drafting	3	31	66	8	57	35
3. Fewer sales items to comprise complete lines (e.g., fewer sizes of bearings or machine screws in standard line, etc.)	4	27	69	4	50	46
4. Fewer production items in inventory (e.g., fewer sizes of taps to match fewer sizes of machine screws, etc.)	3	32	65	3	59	38
5. Economies in the manufacturing process	7	31	62	10	56	34
6. Expanded exports	4	29	67	7	60	33
7. Decrease of competitive imports	2	30	68	2	63	35
8. Improved competitive position	4	28	68	9	58	33
9. Increase of domestic sales	0	34	66	0	67	33
10. Simplified specifications, cataloging and records	10	28	62	21	50	29
11. Improved intra-company liaison and records	7	27	66	25	43	32
12. Other advantages	3	10	87	8	16	76

Table II–10b. Specified disadvantages for companies that use metric measurement units and/or engineering standards (ques. 5d, app. E–II, table 9)

Specified disadvantage	Response of metric users to question on disadvantages experienced in use of metric measurement or engineering standards in 11 specified areas					
	Percent of total metric users			Percent of total employment of metric users		
	Yes	No	Don't know and no answer	Yes	No	Don't know and no answer
1. Training personnel	11	38	51	22	49	29
2. Dual dimensioning or duplication of drawings	20	24	56	40	30	30
3. More sales items to comprise complete lines (e.g., more sizes of bearings or machine screws in standard line, etc)	6	29	65	9	52	39
4. More production items in inventory (e.g., more sizes of bearings or machine screws etc.)	9	28	63	17	46	37
5. Increased waste in the manufacturing process	6	31	63	3	60	37
6. Difficulty in obtaining metric sized parts and tools	22	26	52	29	41	30
7. Increase of competitive imports	2	33	65	4	58	38
8. Impaired competitive position	3	33	64	5	57	38
9. Decrease of domestic sales	1	35	64	0	63	37
10. Conflict with existing statutes	2	33	65	1	58	41
11. Impaired intra-company liaison and records	4	31	65	9	59	32
12. Other disadvantages	0	16	84	0	17	83

the metric system was cited as an advantage by a considerable number of firms, particularly in the less measurement-sensitive industries. The use of the metric system was judged as not having had much effect one way or the other on the number of sales items for a complete line, waste or economies in the manufacturing process, competitive imports and exports, or domestic sales.

There does not appear to be any specific outstanding advantage of metric usage. However, dual dimensioning or duplication of drawings and the difficulty of obtaining metric-sized parts and tools were singled out as outstanding disadvantages companies had found with their use of the metric system. These two items were especially disadvantageous to firms producing components, instruments and dimension materials. Other significant disadvantages were training of personnel and the necessity for keeping more production items in inventory.

All companies, including those using metric measurement units, were also asked to answer the same questions (ques. 12a, 12b, 12c) on the assumption that "a coordinated national program of metrication based on voluntary participation is followed in most sectors of the economy." The discussion of the results of a comparison of responses to questions 5c, 5d, and 5e with responses to questions 12a, 12b, and 12c is given below in B.1.

e. Over-All Experience of Metric Users (ques. 5e, app. E-II, table 10). Metric users were also asked to give their over-all opinion as to how the "advantages and disadvantages relate to each other," in the sense of whether advantages outweigh disadvantages, or vice versa. The results are summarized in table II-10c.

Table II-10c. Opinions on the overall relation of advantages to disadvantages of metric use for companies that use metric measurement units and/or metric engineering standards in specified activities by employee size class and SIC category (ques. 5e, app. E-II, table 10)

	Advantages outweigh		Disadvantages outweigh	
	Percent of companies	Percent employment of companies	Percent of companies	Percent employment of companies
Total	17	25	9	14
By employment size classes:				
1–49	9	9	9	9
50–499	18	16	8	9
500–2,499	32	27	6	7
2,500+	27	26	13	17
By broad industry groups:				
Category A – Selected finished machinery and equipment	11	24	11	24
Category B – Selected components, instruments, and dimension materials	10	18	11	10
Category C – Other	25	30	6	12

It should be noted that a majority of firms reported "no significant difference," "don't know," or did not reply to the question at all. As was the case for individual advantages and disadvantages (d above), the larger metric users reported more nearly completely. Manufacturing employment tended to be "favorable" in about the same ratio as was the count of companies as shown in table II-10c.

In reporting their actual experience in using the metric system for questions 5c and 5d (above), most of the smaller companies responded with a "don't know" or gave no answer rather than definitely specifying an individual activity as an advantage or disadvantage. The larger concerns, perhaps because they had more experience with or knowledge of the metric system, usually took a definite position. Thus, while an average of about a third of the companies specifically answered that an activity was or was not an advantage or disadvantage, the manufacturing employment represented by the same replies was about two-thirds. In total, more positive responses were given under activities for disadvantages than under activities for advantages. However, in answer to the question, "In your opinion, how do advantages and disadvantages relate to each other?" about twice as many companies reported "advantages outweigh disadvantages" as reported "disadvantages outweigh advantages."

Companies in the smallest-size class and in SIC category A (finished machinery and equipment) were evenly divided between "advantages outweigh disadvantages" and the reverse. In SIC category B (components, instruments and dimension materials) the number of companies was about evenly divided, but the number of employees in firms reporting "advantages outweigh disadvantages" was nearly twice those in firms taking the reverse position. All other size classes and SIC categories reported more "advantages outweigh disadvantages" than the reverse.

2. PLANNED METRIC USAGE

a. General Characteristics of Companies (ques. 6, app. E-II, table 11). Of the companies *not now using* metric measurement units and/or engineering standards, few companies (1%) stated that they have specific plans to do so in the next 5 years. Those that do have such plans were chiefly concentrated in the largest employment size classes and in category A (finished machinery and equipment) and category B (components, instruments and dimension materials). About 4 percent of the employment of metric nonusers is represented in the companies planning to introduce metric.

b. Anticipated Metric Use in Specified Activities (ques. 6a, app. E-II, tables 12 and 13). Most of the few companies planning to introduce the metric system intend to use it in (1) design, engineering, and shop drawings, (2) catalogues, (3) research and development, and (4) manufacturing processes. Less than half the companies expect to use metric measurement in labeling.

Metric usage as a proportion of total usage of measurement units and/or engineering standards in the specified activity is expected to be about one-third (when employment-weighted) each in design, engineering, and shop drawings; catalogues; and research and development, and considerably less in manufacturing processes and labeling.

3. FACTORS INSTRUMENTAL IN THE USE OR PLANNED USE OF THE METRIC SYSTEM (ques. 7, app. E-II, table 14)

Companies using or planning to use metric measurements and/or engineering standards in their domestic operations were asked to check "yes" or "no" as to whether each of five specified factors (or other factors) were instrumental in their decision to use metric. The five specified factors were (1) economies resulting from simplification due to use of metric units; (2) expectation of increased export market; (3) economy of importation of standard metric components; (4) advantages resulting from having one basic system of measurement in worldwide production; and (5) mating with standard design components.

On the average, approximately two-thirds or more of the companies were in the "no answer" classification for question 7, and did not indicate that either "yes, the individual decision factor was instrumental in their course of metric action," or "no, it was not."

The percentage of all companies checking a factor as instrumental in their course of action ranged from 23 percent for factor (5) to 7 percent for factor (3), and checking a factor as not instrumental ranged from 23 percent for factors (2) and (3) to 4 percent for "other factors."

"Advantages resulting from having one basic system of measurement in worldwide production" was checked "yes" by a seventh of the metric users (representing 31% of the total employees). Next in line, in terms of manufacturing employment represented, were: "mating with standard metric design components" (one-fourth of the total employment of metric users); "other factors" and "expectation of increased export market" (one-fifth); "economies resulting from simplification due to use of metric units" (one-sixth), and "economy of importation of standard metric components" (one-eighth). Producers of finished machinery and equipment, in particular, saw advantages in having one basic system of measurement for worldwide production but reported that "economy of importation of standard metric components" was the least instrumental factor in their course of action.

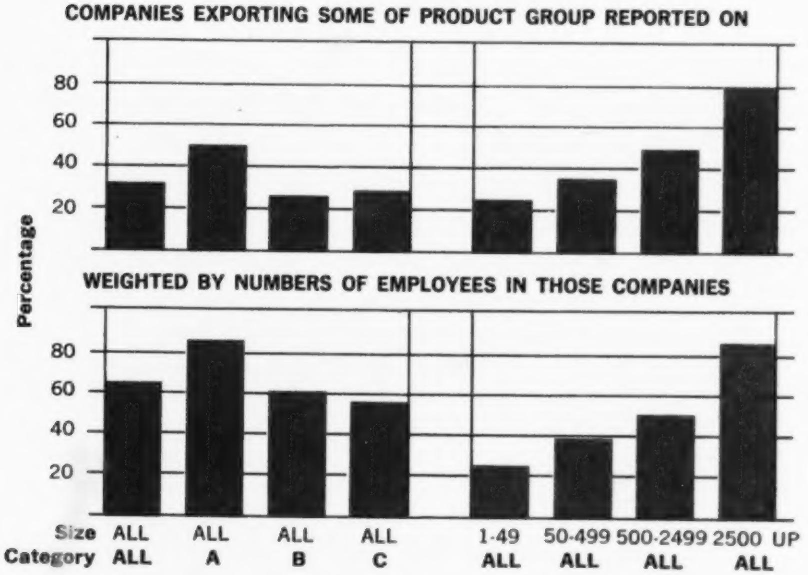
4. USE OF MATERIALS OR COMPONENTS DESIGNED TO METRIC ENGINEERING STANDARDS (ques. 8, app. E-II, table 15)

Approximately 8,500 companies (with about 4,000,000 employees) use at least some materials or components designed to metric engineering standards. Companies both using the metric system and producing in customary units exclusively are included in this group. Two-thirds of these companies (with three-fourths of these employees) used bearings designed to metric measurement units, and about one-third used metric fasteners. Firms in category A (producing finished machinery and equipment) used proportionately less metric standard components than other producers except for "bearings" and "other" items. Metric electrical connectors and fuses were used by 20 percent of the companies (with a fourth of the employees). This usage was especially prevalent for SIC category C ("all other" industries), in which 44 percent of the companies used metric electrical connectors and fuses. A relatively small number, 5 to 9 percent, of companies (with about 10% of employment) used pipe and pipe fittings, sheet, barstock, etc., in metric sizes. The very small companies (1-49 size class) confined the majority of their use of metric components chiefly to fasteners and bearings (27 and 65% of the smallest companies, respectively). Twenty-three percent of all responding companies for question 8 indicated that they used metric engineering standards in their domestic operations for areas other than the five items listed on the questionnaire.

5. EXPORT OF PRODUCTS MANUFACTURED IN THE UNITED STATES

a. Exports in Relation to Total Sales (ques. 9 and 9a, app. E-11, tables 16 and 17 and fig. 2). One-third of U.S. manufacturing companies (with two-thirds of manufacturing employment) export at least some of their output. The larger the concern the more likely it is to export, and this relationship prevails within all industry groups. Four-fifths of the companies in the largest size class (2,500 or more employees) had some export products. Most of the exporting companies (72%), particularly the smaller ones, reported that they exported less than 5 percent of their output. About a quarter of the exporting companies exported from 5 to 25 percent. About 9 percent of companies with 500 and over employees exported more than 25 percent.

FIGURE 2


COMPANIES EXPORTING SOME OF PRODUCT GROUP REPORTED ON

WEIGHTED BY NUMBERS OF EMPLOYEES IN THOSE COMPANIES

Half the companies in SIC category A (finished machinery and equipment) exported as compared with 26 and 29 percent for the two other industry categories. Not only did a large proportion of the producers in this category export, but they exported a larger proportion of their total output.

b. Metric Modifications in Products Exported (ques. 9b, app. E-11, table 18). A greater percentage of the larger-sized as compared to the smaller-sized exporting companies stated that exporting of the reported SIC product group necessitated changes or modifications in this product for each of the seven specified categories. The larger-sized companies also had a higher response rate for this question. Companies having 30 percent of total employment of such exporters cited changes or modifications in labeling, and companies having 27 percent of employees indicated the need for changes or modifications in the descriptions category. Approximately a fifth of employment was in companies mentioning changes or modifications in instructions. At a somewhat lower level (14%) was the necessity of changes or modifications on dials, gauges, etc.; and relatively small proportions of employment (5-9%) were in companies that exported products designed to metric modules, in metric-size containers, or with metric engineering standards. Companies in SIC category A (finished machinery and equipment) reported the highest percentages of employment in the categories of instructions, in descriptions, and on dials and gauges (29, 31, and 25%, respectively). Similarly, companies in SIC category B (components, instruments, and dimension materials) reported the highest percentages of employment in the labeling and description categories (29 and 28%); and companies in SIC category C (other) reported the highest percentage of employment in the instructions category (39%).

6. MANUFACTURING AGREEMENTS OR OPERATIONS IN FOREIGN COUNTRIES

a. Company Characteristics (ques. 10, app. E-II, table 19). Ten percent of the companies have manufacturing agreements or operations in foreign countries. Like export activities, this characteristic is closely related to size so that companies operating abroad account for one-half the employment. Companies in SIC category A (finished machinery and equipment) have relatively more foreign operations (15% of companies and 70% of employees) than do those in other industries (less than 10% of companies and 50% of employees). In all industry groups, a higher percentage (87, 74, and 75% for SIC categories A, B, and C, respectively, employee-weighted) of companies in the 2,500 or more employee size class have agreements and operations abroad than do companies in the smaller size classes.

b. Use of Metric System (ques. 10a, app. E-II, table 20). As a rule, manufacture under agreements or operations in foreign countries involves the use of metric units and/or metric engineering standards. Ignoring those companies in the smallest-size class (1-49 employees), which are inconsequential in foreign operations, three-fourths of the companies in all other employee size classes involved in such manufacture used metric units and/or metric engineering standards in their foreign activities. Similarly, one-half to three-fourths of the companies in all SIC categories used the metric system in their foreign activities.

7. MANUFACTURE IN THE UNITED STATES UNDER AGREEMENT WITH A FOREIGN COMPANY (ques. 11, app. E-II, table 21)

Only 2 percent of the number and about 11 percent of the employment of companies in the survey reported that they manufactured in the United States under agreement with a foreign company. These companies were the larger ones (500 and over employees) and mostly in SIC category B (selected components, instruments, and dimension materials) and SIC category C ("all other" industries). Over 60 percent of all responding companies did not answer question 11 either way, and the majority of the 39 percent that did failed to answer question 11a regarding translation of customary units in their operations.

B. COMPANY RESPONSES TO SELECTED QUESTIONS UNDER THE ASSUMPTION THAT THERE WOULD BE A COORDINATED NATIONAL PROGRAM OF METRICATION—PART A SURVEY

1. ADVANTAGES AND DISADVANTAGES OF METRIC USE TO COMPANIES ASSUMING A COORDINATED NATIONAL PROGRAM OF METRICATION BASED ON VOLUNTARY PARTICIPATION

a. Metric Users (ques. 12a, 12b, and 12c, app. E-II, tables 22-28)

(1) General Comparison with Information Reported Under Existing Conditions. Companies using the metric system were asked to answer the same questions regarding advantages and disadvantages of metric usage that they had previously answered based on their actual experience (ques. 5c, 5d, and 5e), but for questions 12a, 12b, and 12c they were asked what they would foresee on the assumption of a coordinated national program of metrication. All other companies (those not using the metric system) were also asked to answer the questions under the assumption of a coordinated national program. The comparison of "for" (advantages outweigh disadvantages) and "against" (disadvantages outweigh advantages) is shown in table II-11, which is based on questions 5e, 12c and 5; and app. E-II, tables 10, 26 and 27.

An important effect on the answers of *metric users* of the assumption of a national program was that there was an increase in the proportion of "yes" or "no" answers in comparison with the "don't know" and "no answer" group. On balance, there was an increase of "advantages" in relation to "disadvantages" by *metric users* under the

Table II–11. Relation of advantages and disadvantages in the use of the metric system (ques. 5e, 12c and 5; app. E–II, tables 10, 26 and 27)

	Under existing conditions		Assuming a coordinated national program in the use of the metric system					
	Metric users		All manufacturers		Metric users		Metric nonusers	
	Firms	Employees	Firms	Employees	Firms	Employees	Firms	Employees
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Advantages outweigh disadvantages	17	25	17	24	25	45	16	16
Disadvantages outweigh advantages	9	14	20	28	13	22	21	30
No difference	19	31	17	24	15	18	17	27
Don't know	22	19	20	12	14	10	21	13
No answer	33	11	26	12	33	6	26	14

assumption of a national program of metrication both in terms of number of companies and manufacturing employment represented.

A higher percent of the nonusers indicate that the disadvantages outweigh the advantages (21%) rather than vice versa (16%) assuming a coordinated national program of metrication.

(2) Changes in Individual Areas of Advantage or Disadvantage. Training of personnel was seen by more metric users as a disadvantage than an advantage for their company (11 versus 7%, respectively) under existing conditions of metric usage (ques. 5c and 5d), but slightly more saw it as an advantage than as a disadvantage (26 versus 20%, respectively) with a coordinated national metrication program (ques. 12a and 12b). It should be noted, however, that the majority of the metric user companies mentioned training of personnel neither as an advantage nor a disadvantage to their company under either present conditions or a coordinated national program, and the same is true for all the other activities for questions 12a and 12b. The detailed tabulations are given in app. E-II, tables 23 and 25.

Under existing metric usage conditions, a higher percentage of metric user companies stated that they experienced disadvantages in the use of the metric system in the two categories of dual dimensioning or duplication of drawings (20%) and difficulty in obtaining metric-sized parts and tools (22%) than in the other categories. A similar result was indicated assuming a coordinated national program of metrication; that is, the two highest percentages of metric user companies were in the same two disadvantage categories (29 and 22%, respectively).

Assuming a national program of metrication, metric users were about evenly divided between those that thought there would be fewer and those that thought there would be more sales items to fill out product lines. "Fewer production items in inventory" was cited as an advantage by 3 percent of metric users, and "more production items in inventory" was cited as a disadvantage by 9 percent of them, under existing metric conditions. The opposite was indicated under a coordinated national program; that is, 13 percent of metric users stated that the need for fewer items would be an advantage, and 9 percent stated the need for more items would be a disadvantage. A larger number foresaw economies in the manufacturing process and an improved competitive position under a national program than under existing metric conditions. With a coordinated national program, metric users, especially the larger concerns, expected a marked improvement in simplified specifications, cataloguing and records, and in intra-company liaison and records.

Whereas metric users had responded affirmatively to more categories of disadvantages than advantages under current conditions, the situation was reversed by the assumption of a coordinated national program.

About twice as many metric users indicated that under existing conditions advantages outweighed disadvantages as indicated the reverse position. This 2 to 1 ratio continued under the assumption of a coordinated national program, but the number of companies reporting an "outweigh" answer increased while those reporting "no significant difference" or "don't know" declined. Under a coordinated national metrication program one-fourth of the metric user companies (with nearly half of the employees) reported that advantages outweighed disadvantages, one-eighth of these companies (with a little less than a fourth of the employment) considered that disadvantages would outweigh advantages. Over 60 percent of the metric user companies (with one-third of the employees) reported "no difference," "don't know," or gave no answer.

b. All Companies (ques. 12a, 12b, and 12c, app. E-II, tables 22-28)

(1) Effect on the Total Responses of Nonmetric Users. In general, the companies that do not use metric measurements foresee an increase in metric use as more disadvantageous than advantageous to their operations. Thus, metric users who had expected that in most specified areas increased metric use would be to their advantage had their response more than offset in the total by the responses from the nonmetric companies. In eight out of nine areas where advantages and disadvantages are similarly described, more manufacturers in total indicated disadvantages rather than advantages. In general, the nonmetric users responded (in higher percentages) only moderately more unfavorably than the metric users under most specific disadvantages, but they responded less favorably than metric users under specific advantages.

(2) All Manufacturers' Response to Specific Areas of Advantages and Disadvantages. Dual dimensioning or duplication of drawings and training of personnel were mentioned as disadvantages by more companies than were other areas, especially by larger companies (app. E-II, tables 22 and 24). At the same time, many companies saw training of personnel and economy in engineering design and drafting as advantages under a coordinated national program of metrication. However, the number that believed that metric use would be advantageous in these areas was only about half as large as the number that believed metric use would be disadvantageous. As with metric users, the difficulty of obtaining metric-sized parts and tools was foreseen as a problem by about a fourth of the number and a third of the employment of all manufacturers. Manufacturers representing 22 and 30 percent of the employees saw the requirement to have more sales items to comprise complete lines and more production items in inventory as disadvantages of metric use. Companies with a third of all manufacturing employees regarded simplified specifications, cataloguing and records as an advantage of metrication, and companies with a fourth of the employees regarded improved intra-company liaison and records as advantages of metric use.

(3) All Manufacturers' Opinion on How Advantages and Disadvantages Relate to Each Other. Whereas about twice as many metric users (with twice the employment) stated that advantages outweighed disadvantages (25%) than stated the reverse position (13%), more nonmetric user companies stated that disadvantages outweighed advantages (21%) than took the reverse position (16%). The net result for question 12c (app. E-II, tables 26 and 27) was that for manufacturing as a whole, somewhat more companies took the position that disadvantages outweighed advantages than the other way around.

A cross-tabulation of questions 12c and 5e shows (app. E-II, table 28) that of the fraction of metric users who gave the opinion "disadvantages outweigh advantages" under existing metric conditions (ques. 5e), 68 percent of these stated the same opinion when answering a similar question but assuming a coordinated national program of metrication based on voluntary participation (ques. 12c), and the remaining 32 percent stated that "advantages outweigh disadvantages" (6%) and that there is "no significant difference" (26%). Similarly, for the fraction of metric users who originally gave the opinion "advantages outweigh disadvantages" 96 percent stated the same opinion under the assumption of a coordinated national program, 3 percent stated that "disadvantages outweigh advantages," and 1 percent stated "no significant difference."

2. NUMBER OF YEARS NECESSARY TO ACHIEVE MAXIMUM INCREASED METRIC USE WITH MINIMUM COST UNDER A COORDINATED PROGRAM OF METRICATION (ques. 13, app. E-II, table 29)

Manufacturers showed a varied response with reference to the number of years necessary for them to achieve maximum increased metric usage with minimum cost and disruption, under a coordinated national program of metrication based on voluntary participation. Sixty-nine percent of the companies did not give any estimate, although half of the large companies did so. About 9 percent of the firms each cited the 1-4, 5-9, and 10-14 ranges. The most commonly reported range (on an employment-weighted basis) was 10 to 14 years. However, this range accounted for only one-fifth of the replies. Higher percentages of smaller companies reported in ranges under 10 years than in ranges over 14 years. A small but economically significant group of large companies (14%) reported the optimum period for metrication would be 20 years or more.

A higher percentage of companies (28%) both in SIC category A, producing assembled mechanical products (machinery and equipment), and in SIC category B, producing other measurement-sensitive products, estimated that 5 or more years would be required to achieve metrication compared to the percentage of companies (12%) in category C, producing less measurement-sensitive products.

3. IMPORTS UNDER A COORDINATED NATIONAL PROGRAM OF METRICATION

a. Companies' Anticipations of Effect on Sales Because of Imports of Metric Products (ques. 14, app. E-II, table 30). Forty-five percent of the manufacturing companies (with two-thirds of all employees) stated that imports under a coordinated national program of metrication would have no effect on their sales. Only 5 percent of all the companies (with 4% of all employees) thought their sales would decline. About one-fourth stated that they didn't know, and one-fourth didn't answer the question.

Companies expecting a sales loss were scattered over the several size classes but were concentrated in the more measurement-sensitive industries, SIC category A (finished machinery and equipment) and category B (components, instruments and dimension materials)—8 and 7 percent of companies, respectively.

b. Range of Losses for Companies Anticipating Decrease in Sales (ques. 14a, app. E-II, table 31). One-fourth of firms with a third of the employment in companies anticipating a sales loss because of importation of metric products thought the loss would be from 10 to 20 percent of 1980 sales. Similarly, 3 percent of firms with a seventh of the employment thought the 1980 sales loss would not exceed 5 percent. Another seventh of the employment was in firms expecting a loss in 1980 sales of more than 20 percent. This latter group consisted chiefly of small companies that accounted for 43 percent of the total number of companies expecting losses. Companies with 30 percent of the employees gave a "don't know" answer rather than indicating a specific range.

4. EXPORTS UNDER METRICATION

a. Expectations of Companies Whose Products Are Not Now Exported (ques. 15, app. E-II, table 32). Of the companies not now exporting, about four-fifths stated that they would not expect to export if the company converted to the metric system (assuming year 1980). Six percent of the firms said they would expect to export, and the remainder did not answer the question. Companies that would expect to export accounted for only about 3 percent of the employment of all nonexporters, and those that would not expect to export had 85 percent of the employment of all nonexporters. Among the nonexporters, relatively more of companies that are already metric users and those that plan to go metric would expect to export (21 and 16%, respectively).

b. Expectations of Companies Whose Products Are Now Exported (ques. 16, app. E-II, table 33). Almost none (1%, with .4% of the corresponding employment) of the companies now exporting would anticipate a decrease in exports if they adopted the metric system. About one-sixth (16%) of the companies (with 18% of employees) would expect an increase in exports. The majority of exporting companies (69%, with 71% of employees) thought that metrication would have no effect on their exports, and 10 percent checked "don't know." A small number did not answer the question. Companies expecting an increase in exports tended to have more than 50 employees.

(1) Range of Increases in 1980 Export Sales Expected by Companies Now Exporting and Who Anticipate an Increase in Export Sales Under Metrication (ques. 16a, app. E-II, table 34). About one-third of the number of companies (with half the employment) that expect an increase in exports think that the increase will not exceed 10 percent. A significant number of producers in SIC category A (selected finished machinery and equipment) and in category B (selected components, instruments and dimension materials) reported anticipated increases of 10-25 percent (12 and 27%, respectively) and some (14%) in category B thought export increases would reach the 25-50 percent range. Very few companies (less than 5% in any size class or SIC category) expected an increase of more than 50 percent.

Over 40 percent of the number (with a third of the employment) of the exporters expecting increases stated "don't know" or did not answer question 16a relative to the range of increases.

(2) Range of Decrease in 1980 Export Sales Expected by Companies Now Exporting and Who Anticipate a Decrease in Export Sales Under Metrication (ques. 16b, app. E-II, table 35). The 1 percent or less of firms who anticipated a decrease (per above for ques. 16) did not follow through with responses to question 16b.

C. MANUFACTURERS' VIEWS ON METRICATION

1. CURRENT ATTITUDE TOWARD INCREASED METRIC USE IN THEIR OWN INDUSTRY

(ques. 17, app. E-II, tables 36-38 and fig. 3)

Manufacturers were asked to state whether their companies were strongly for, mildly for, neutral, mildly against, or strongly against increased metric use for the SIC product being reported. The company response rate on this question was 96 percent. Table II-12 summarizes the responses. In total, on the basis of firms responding to question 17, there were slightly more companies against metrication (34%) than there were for it (26%). In terms of the distribution of employees, manufacturing as a whole was moderately for metrication (37% for and 28% against). Thirty-nine percent of the firms (with 35% of the employment) were neutral in their current attitude.

a. By Size and Industry Characteristics. The smaller companies, 1-49 and 50-499 employee size classes, were more against metrication (38 and 32% against versus 28 and 25% for, respectively), while the larger companies, 500-2,499 and 2,500+ employee size classes, definitely favored metrication (37 and 41% for versus 23 and 28% against, respectively). Similarly, on an employment-weighted basis, the smaller firms were against increased metric use and the larger firms were for increased metric use.

In terms of employment, producers of finished machinery and equipment, SIC category A, registered more strongly for and strongly against than did producers in SIC categories B and C. Companies producing components, instruments, and dimension materials, SIC category B, were about evenly divided for and against (32% each), while company employment in SIC category C favored metrication (40% for and 23% against).

b. Metric Users and Nonusers. As would be expected, metric users' current attitudes toward increased metric use in their own industry were much more favorable (47% of companies were for) than were the attitudes of nonusers (24% of companies were for). On the unfavorable side of current attitude, metric users were only 8 percent against metrication in their own industry while nonmetric companies were 37 percent against.

On an employment basis, metric firms were 53 percent and nonmetric firms were 31 percent favorable in their current attitude toward metrication in their own industry. Metric companies with a nonfavorable current attitude had 16 percent of employment, and nonmetric companies not currently favorable to metrication in their own industry had 33 percent of employment.

Forty-six percent of metric firms and 38 percent of nonmetric firms were neutral in their current attitude toward metrication for their own industry. The neutral percentage was less on the basis of employment, with 30 percent of the metric firms' employment belonging to neutral companies and 37 percent of the employment of firms not using metric measurements belonging to neutral companies.

Thus, metric users were much more favorable than unfavorable in their current attitude toward increased metric usage in their own industry on the basis of both number of companies and employees. Nonmetric firms had a more unfavorable current attitude based on number of companies, but were about equally divided between favorable and nonfavorable on the basis of employment.

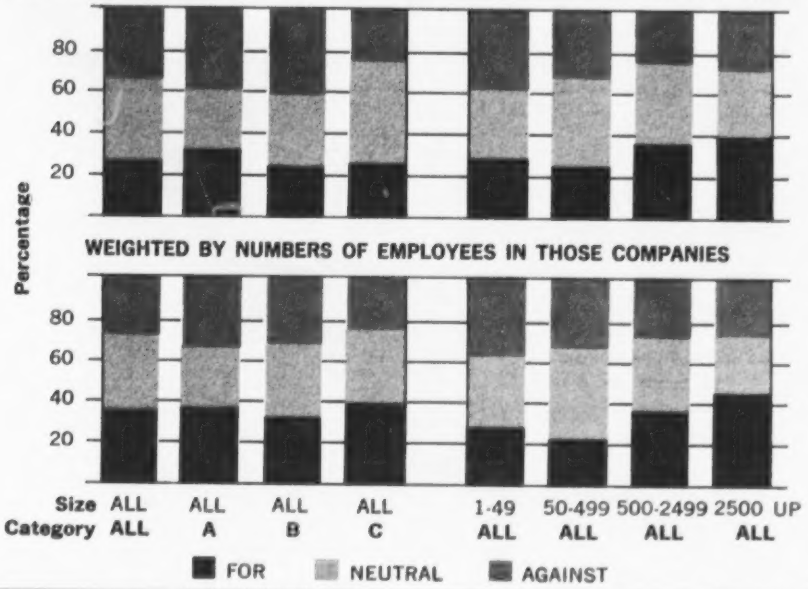
Table II–12. Current Attitude Toward Increased Metric Usage in Company's Industry—Percent of all firms responding to question 17 (app. E–II, tables 37 and 38).

	Number of companies						Number of employees					
	Total	Strongly for	Mildly for	Neutral	Mildly against	Strongly against	Total	Strongly for	Mildly for	Neutral	Mildly against	Strongly against
Total	100	10	16	39	18	16	100	8	29	35	17	11
By employment size of company:												
1–49	100	16	12	34	15	23	100	16	12	34	15	23
50–499	100	6	19	43	20	12	100	6	17	44	21	13
500–2,499	100	10	27	40	15	8	100	9	28	37	18	8
2,500+	100	10	31	32	16	12	100	9	36	30	15	11
By industry category:												
A. Selected finished machinery and equipment	100	14	17	29	15	24	100	12	25	29	18	15
B. Selected components, instruments, and dimension materials	100	14	11	35	23	18	100	6	26	35	21	11
C. Other	100	5	21	50	14	10	100	8	32	37	13	10
Metric users	[1] 100	23	24	46	5	3	100	15	38	30	12	4
Nonusers	[1] 100	9	15	38	19	18	100	6	25	37	19	14

[1] Figures from app. E–II, table 38 have been recalculated using firms responding to question 17 on the base = 100.

FIGURE 3

COMPANY ATTITUDE TOWARD INCREASED METRIC USE FOR PRODUCT GROUP



2. VIEWS AS TO WHETHER OR NOT INCREASED METRIC USE IS IN THE BEST INTERESTS OF THE UNITED STATES (ques. 18, app. E-II, tables 39-41)

Table II-13 shows the responses to the question of whether or not the company believes that increased metric usage is in the best interests of the United States (fig. 4 shows the responses to the question after excluding "no answer"). Sixty percent of all companies questioned, accounting for 76 percent of employment, indicate that increased metric usage is in the best interests of the United States.

a. By Size Class and SIC Category. Companies in each individual size class and in each SIC category predominantly believe that increased metric usage is in the best interests of the United States (from 55 to 79% for "yes" compared to from 16 to 35% for "no"). Large companies held this view to a greater extent than did small ones (large companies were 5 to 1 affirmative, and small companies were only 1 1/2 and 3 to 1 affirmative). More companies in SIC category B than in SIC category A or C believed that the best interests of the United States would be served by increased metric usage (65% for B compared to 61 and 55% for A and C).

b. Metric Users in Comparison with Nonmetric Users. Seventy-two percent of all metric users (with 85% of the employment) replied that increased metric usage would be in the best interests of the United States. The correspond-

Table II–13. Company's belief as to whether or not increased metric use is in the best interests of the United States (ques. 18, app. E–II, tables 3, 39, 40, and 41)

	Percent of companies				Percent of employees			
	Total	Yes	No	No Answer	Total	Yes	No	No Answer
Total	100	60	27	13	100	76	17	7
By employment size class:								
1–49	100	56	35	9	100	56	35	9
50–499	100	61	21	18	100	64	21	16
500–2,499	100	79	16	5	100	80	15	4
2,500 +	100	78	16	6	100	81	15	4
By industry category:								
A. Selected finished machinery and equipment	100	61	35	4	100	77	21	2
B. Selected components, instruments, and dimension materials	100	65	25	11	100	78	16	6
C. Other	100	55	23	21	100	73	16	11
Metric users	100	72	17	11	100	85	11	4
Nonusers	100	58	28	14	100	72	20	9
By attitude on increased use in own SIC category:								
Strongly for	100	100	0	0	100	99	1	0
Mildly for	100	98	2	0	100	99	1	0
Neutral	100	62	17	20	100	78	10	11
Mildly against	100	51	40	9	100	65	26	8
Strongly against	100	16	77	7	100	12	82	6

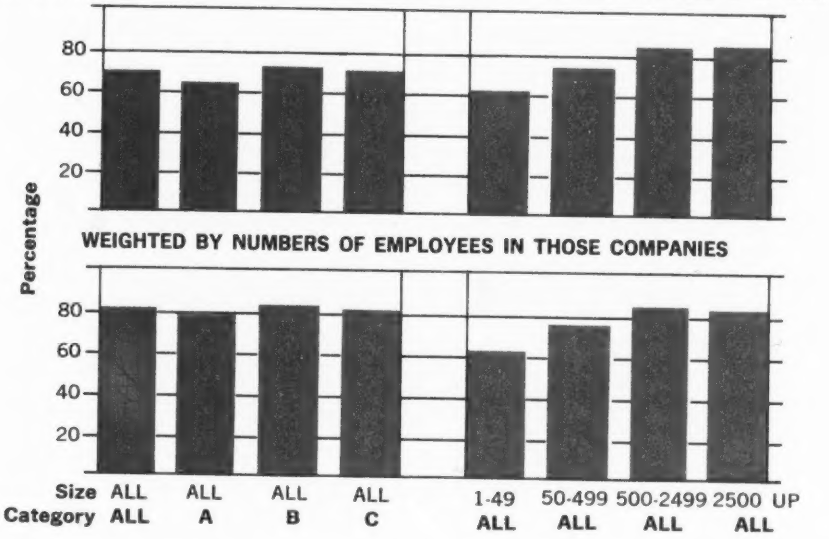
ing affirmative reply figures for nonmetric users were 58 percent of companies and 72 percent of employees. Relatively more metric users than nonusers in all size classes and SIC categories responded that increased metric usage is in the best interests of the United States. The ratio of the percentage of companies replying "in best interests" to those replying "not in best interests" ranged from 11 to 1 down to 3 to 1 for metric users and from 4 to 1 down to 1 to 1 for firms not using metric measurements.

c. By Attitude Concerning Increased Metrication In Their Own SIC Category. Nearly all companies that were "strongly" or "mildly" for metrication in their own industry believed that to increase metric use is in the best interests of the United States. A fifth of the companies that had been neutral on the metrication of their industry did not take a position on increased metric use in the United States, but of the remaining four-fifths that had been neutral, 62 percent (with 78% of the employees) took the view that increased metric use was in the best interests of the country.

The majority of companies (51%, with 65% of employment) that had been "mildly against" metrication for their own industry still considered it in the

FIGURE 4

COMPANIES BELIEVING INCREASED METRIC USE IS IN BEST INTERESTS OF U.S.



best interests of the country to increase metric use. In the 1-49 employee size class companies that had been "mildly against" increased metric use in their own industry also thought it was not in the best interests of the United States to go metric (36% now for and 61% now against). The majority of all companies in the other three size classes of this "mildly against" group thought that it would be in the best interests of the United States to increase metric use. Also, SIC category A companies that had been "mildly against" their own industry's metrication believed that metrication was not in the best interests of this country (53%), while a majority of those companies in SIC categories B and C (54 and 53%, respectively) believed metrication was in the best interests of this country even though they had mildly opposed increased metrication for their own industry.

Companies that had been "strongly against" believed that it would not be in the best interests of the United States to increase metric usage. In this "strongly against" group the ratio of those who regarded increased metric usage as not in the best interests of the United States to those holding the reverse view was about 5 to 1; it was about 3 to 1 for "strongly against" companies producing components, instruments and dimension materials (SIC category B), and higher (6 to 1 and 13 to 1) in other industries (SIC categories A and C, respectively).

3. COURSES TO BE FOLLOWED IF INCREASED METRIC USE IS FOUND TO BE IN THE BEST INTERESTS OF THE UNITED STATES (ques. 19, app. E-II, tables 42-44 and fig. 5)

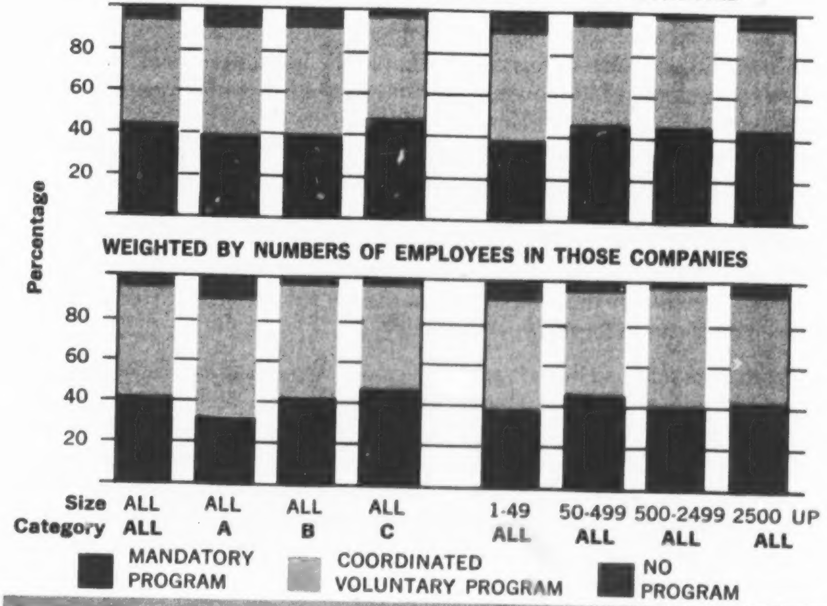
Companies were asked for their opinions as to which of three courses of action would be preferred in the event that increased metric use was found to be in the best interests of the United States. The alternatives were (1) no national program of metrication, (2) a coordinated national program based on voluntary participation, and (3) a mandatory program based on legislation. The company response rate on this question was 92 percent.

Half the companies responding to the question preferred a coordinated national program based on voluntary participation. About 43 percent preferred a mandatory program based on legislation, and a few (6%) preferred no national program of metrication. About the same results were also indicated on the basis of employment. This general pattern prevailed in all employee size classes and SIC categories.

On the basis of the cross-tabulation of question 19 with question 5, the percentage results for companies were:

	Metric user	*Non-metric user*
No program	3	6
Voluntary program	47	46
Mandatory program	49	39
No answer	1	9

FIGURE 5



COMPANY PREFERENCE IF METRIC USE IS TO BE INCREASED

WEIGHTED BY NUMBERS OF EMPLOYEES IN THOSE COMPANIES

Metric users and nonusers were about equal on the percentage of companies preferring a coordinated national voluntary metrication program (47 and 46%, respectively). The preference percentage for the mandatory legislated program by metric companies was 49 and by nonmetric companies was 39. On an employment basis, metric users were 52 percent for a coordinated national program compared to 49 percent for the nonusers; and were 41 percent for the mandatory legislated alternative compared to 40 percent for the nonusers. In the case of metric users, both the 50-499 employee size class and SIC categories B and C had a higher percentage of companies favoring the mandatory rather than voluntary metrication program (59 versus 38%, 62 versus 32%, 55 versus 44%, respectively). The percentage of nonmetric companies in all size classes and SIC categories for a mandatory legislated program was equal to or less than the percentage for a coordinated national voluntary program.

4. RETENTION OF ENGINEERING STANDARDS BASED ON CUSTOMARY MEASUREMENT UNITS IF INCREASED METRIC USAGE IS IN THE BEST INTERESTS OF THE UNITED STATES (ques. 20, app. E-II, table 45)

Less than a third of all the companies included in the survey (with about half of the employees) gave "yes" or "no" answers to question 20, which relates to retaining and promoting any engineering standards based on the customary system of measurement units for the primary SIC product if increased metric usage is in the best interests of the United States. The answers were negative as to the retention of standards in customary measurement units by a ratio of more than 2 to 1, both in respect to number of firms and number of employees covered. This was the general pattern in most size classes and industry categories, except for the employment-weighted percentages in the finished machinery and equipment category (A).

Forty-five percent of the companies did not know if any engineering standards based on the customary system of measurement units and applicable to their SIC category should be retained and promoted for international use; and one-fourth of the firms did not answer the question.

D. GENERAL COMMENTS—PART A SURVEY

Respondents were invited to make additional comments regarding the subject of metric usage (ques. 21). Fewer than 10 percent of the respondents submitted such comments. In this section of the report, firms providing these additional comments are classified as either small (1-499 employees) or large (500 or more employees) and as present metric users or present nonusers. The analysis below shows how these firms are distributed among the classification groups.[2]

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[2] Note: The data presented in this section are unweighted summaries of the comments received.

Metric user status	Size		
	Small	Large	Total
Present user	14	40	54
Present nonuser	44	61	105
Total	58	101	159

Topics mentioned most frequently are summarized in the following paragraphs. Random samples of comments from each of the classification groups are presented in appendix D.

Two-thirds (107) of the commenting companies mentioned economic effects that metric usage has or would have on their operations.

Economic effect	Total number	Number of small users	Number of large users	Number of small nonusers	Number of large nonusers
Total	107	7	22	42	36
Negative effect	77	5	8	36	28
Positive effect	13	1	5	3	4
No effect	17	1	9	3	4

A larger proportion of users (21%), as compared with nonusers (9%), sees some positive effects of metric usage. Some positive effects mentioned were increased international trade, elimination of present dual-dimensioning systems in foreign operations, and fewer sizes in certain product lines. However, the large majority of the commenting companies indicated negative economic effects resulting from metric usage. These negative effects covered areas such as costly machinery replacement, dual inventory, dual manufacturing systems, retraining of personnel, and the large cash outlay necessary in these areas. In addition, several companies (14) indicated that the metrication costs to them would not be compensated by foreseeable advantages or increase in sales.

A few companies had suggestions as to how the economic burden on manufacturers could be lessened. Six companies suggested that the federal government provide some economic relief to companies in the form of loans, subsidies, or tax relief.

Another group of comments centered around the questions of what type of national program of metrication should be undertaken and the duration of such a program. The majority of the 23 commenting companies felt that there should be a mandatory program. These companies fell into two general groups with regard to the reasons behind wanting a mandatory program. One group cited practical problems for their companies if the program were not mandatory. Some of these companies felt that unless the change were mandatory, necessary metric parts would not always be available when needed. Others in this group felt that a mandatory program was necessary to maintain their relative competitive position. The second group showed opposition to metrication and indicated that the only way their company would transfer to the metric system would be if they were required by law to do so. With regard to the time period of transition to metric, most commenting companies felt that a long period was preferable so that costs were spread over a longer time.

The need of a world system of measurement was frequently mentioned (16).

A total of 29 of the comments were related to employee training (17) and public education (12), there being a feeling that increased education of the public with respect to the metric system would alleviate the employee training problem and reduce public misunderstanding from the use of metric units in consumer products.

E. SAMPLING ERRORS FOR PART A SURVEY RESULTS

Sampling errors have been estimated from the data and are included in this report (table II-14) for the principal summary measures for all companies. The results presented in the table are estimated standard errors. From the results in table II-14 it is seen that while some of the sampling errors are not small, many are, and they are generally small enough to support general conclusions from the data.

A consequence of the sample design is that the sampling errors generally will be smaller for employment-weighted percentages or aggregates than for company counts. It follows also that sampling errors will be quite small for any data presented for the largest employee size class (2,500 or more employees) because most of the companies in this size class are included in the sample. Sampling error will be relatively larger for the size class 500-2,499, and considerably larger for the two smallest size classes (1-49 and 50-499). In the case of data for SIC categories, again, the sampling errors will be larger for the company counts than for the employment-weighted statistics. The sampling errors get particularly large for data presented for a subclass of items (as for users of the metric system) within either SIC categories or size classes (except for the larger size classes) because users constitute a small fraction of the total. Thus, the number of companies in the sample that have less than 50 employees and that are metric users is very small, and consequently, any statistics for such user companies will have quite large relative sampling errors.

The data for computing sampling errors for some of the more detailed statistics are available in computer hardcopy printout sheets that are not included in this report. These data include many of the results presented by size of company, and by SIC category, but not for cells crossing SIC category and size class. The printouts contain results for ten subsamples, for selected tabulations.

The sampling errors presented in table II-14 are for the specific estimates shown in the table. Often one is interested in sampling errors of differences, or for ratios other than those shown. Any of these can be computed in a simple manner by calculating the desired measures for each of the ten subsamples. The sampling error of any measure computed for the total sample is approximately 1/10 of the difference between the largest and smallest estimate

Table II–14. Some summary statistics and estimated standard errors, part A survey

Text reference	Percent of companies		Percent of employees	
	Estimate	Standard error of estimate	Estimate	Standard error of estimate
Table II–3 (ques. 5):				
Metric measurement usage (to any extent)				
Total	11	2.8	28	1.5
Employment size class:				
1–49	8	2.1	8	2.2
50–499	12	4.3	16	5.2
500–2,499	24	4.3	25	4.6
2,500+	31	1.7	37	1.4
Industry category:				
A. Selected finished machinery and equipment	12	3.1	30	.8
B. Selected components, instruments and dimension materials	9	2.7	25	3.4
C. All other	13	6.2	29	2.5
Table II–4 (ques. 5a):				
Metric measurement usage by metric users and by activity:				
Design, engineering and shop drawings	40	7.9	45	2.9
Catalogues	17	5.1	29	2.1
Research and development	56	6.2	80	2.3
Manufacturing process	58	6.0	53	3.5
Labeling	21	6.5	33	4.3
Other	9	5.4	10	4.2
Text p. 37, 2a (ques. 6): Companies not now using metric measurement and having plans to do so within 5 years	1	.4	4	.3
Text p. 39, 5a (ques. 9a): Exports as percent of total sales:				
Less than 5	72	2.8	60	2.2
5–25	23	2.5	30	1.8
Greater than 25	2	.9	6	1.9
Text p. 40, 6a (ques. 10): Companies with foreign operations	10	2.3	50	1.9
Text p. 45, 4a (ques. 15): Companies not now exporting and expecting to export	6	1.5	3	.8
Text p. 46, 4b (ques. 16): Expected change in exports:				
Decrease	1	.8	.4	.1
No effect	69	3.7	71	1.4
Increase	16	2.9	18	1.2

Table II–14. Some summary statistics and estimated standard errors, part A survey—Continued

Text reference	Percent of companies		Percent of employees	
	Estimate	Standard error of estimate	Estimate	Standard error of estimate
Table II–12 (ques. 17): Attitudes toward increased metric usage (in own industry):				
All companies:				
Strongly for	10	2.8	8	1.1
Mildly for	16	1.8	29	1.2
Neutral	39	2.8	35	1.6
Mildly against	18	2.2	17	1.9
Strongly against	16	1.3	11	.7
Metric users:				
Strongly for	23	4.4	15	2.0
Mildly for	24	6.6	38	3.1
Neutral	46	6.3	30	2.8
Mildly against	5	2.5	12	1.0
Strongly against	3	.7	4	.3
Nonusers:				
Strongly for	9	2.4	6	.9
Mildly for	15	2.1	25	1.2
Neutral	38	3.1	37	2.0
Mildly against	19	2.1	19	2.3
Strongly against	18	1.7	14	.8
Table II–13 (ques. 18): Companies believe metric use in best interests of U.S.:				
All companies	60	1.6	76	1.1
Metric users	72	7.2	85	1.9
Nonusers	58	2.1	72	1.5
Text p. 52, 3 (ques. 19): Courses toward increased metric use:				
No national program:				
All companies[1]	6	.6	5	.3
Metric users	3	1.1	3	.3
Nonusers	6	1.0	5	.4
Coordinated national program:				
All companies[1]	50	2.7	53	1.9
Metric users	47	7.1	52	3.5
Nonusers	46	2.9	49	2.1
Mandatory program:				
All companies[1]	43	2.2	42	1.7
Metric users	49	7.4	41	2.7
Nonusers	39	2.1	40	2.1
Number of employees (1,000,000)			11.4	.3

[1] Note: The above percentages under ques. 19 for "all companies" are based on all firms responding to the question, and the percentages for "metric users" and "nonusers" are based on all firms, including "no answers."

of the measure obtained from the ten subsamples. The sampling errors in table II-14 were not computed by this simple procedure, and are slightly more precise estimates of the sampling error. The two methods for computing the estimates of sampling errors are given in appendix A, section 2d.

F. TIME AND COST IMPLICATIONS UNDER THE ASSUMPTION THAT THERE WOULD BE A COORDINATED NATIONAL PROGRAM OF METRICATION—PART B SURVEY

In an effort to develop information on the cost in dollars and the time in years that would be involved in increasing metric usage to the greatest feasible extent in the manufacturing companies in the United States, the U.S. Metric Study included in the Manufacturing Survey questionnaire Part B—Cost, a section 1 for companies reporting on product groups other than standard parts or materials, and a section 2 for product groups that are standard parts or material. The questionnaire appears in appendix B. This questionnaire was sent to a limited number of manufacturing companies, mostly but not all large, that had agreed in advance to do the relatively extensive work necessary to provide data under a specified set of assumptions.

Evidence that this negotiated approach was a reasonable procedure to adopt is provided by the fact that an attempt to collect information from a very small probability sample of companies yielded a response of less than 25 percent—hardly enough to evaluate the validity of the study of costs. It is essential, therefore, to recognize the limitations of the survey and to use the results with caution. The characteristics of the cooperating companies are examined in appendix A, and some reassurance is provided by the nature of the companies covered.

Data from 126 manufacturing companies are included in the tabulations. The data collected on form B, as for form A, relate to a specified SIC product group, usually the principal SIC product group of the company. In some instances, however, a company submitted a form B report for an SIC product group other than its principal SIC product group, and in some instances a company submitted a form B for two or more SIC product groups. The same general comments as made for the interpretation of form A (see introduction to this chapter) apply here, i.e., although the data relate to specific SIC product groups of a company, in the interests of simplification of presentation, the discussion is generally presented as though the particular SIC product group represents the entire production of the company.

1. THE SAMPLES FOR THE PART B SURVEY

As described more fully in appendix A, two small samples and one very small sample were available of companies responding on form B, covering cost and timing implications of increased metric usage under the assumption of a national coordinated metric program. The three samples have been designated Samples 1, 2, and 3. The respondents on Samples 1 and 2 were consolidated into what is referred to as Sample B, and provide the basis for the principal analysis of cost and time implications.

The respondents in Sample 3 responded to an invitation to cooperate in the part B study that was included in the instructions to the companies selected for the part A sample (who were also sent a form B along with a form A). The mailed instructions requested that any of these companies that had an interest in cooperating in the part B study should communicate with the staff of the National Bureau of Standards to learn more specifically what was being asked of respondents on form B, and to obtain supplemental instructions and guidance so that the studies would be carried out on a reasonably adequate and comparable basis. Accordingly, some companies communicated with the National Bureau of Standards, were given the necessary instructions, and were included in Sample B.

However, usable responses were also received from an additional group of approximately 100 companies, most of them relatively soon after the first mailing, that did not follow the procedure of communicating with the National Bureau of Standards personnel to get additional instructions and guidance before completing form B. Consequently, there is reason to be concerned as to whether the necessary background work was done by such companies as a basis for completing form B, and, accordingly, there is reason to question the adequacy of the responses obtained in Sample 3. The decision was made, therefore, to tabulate these returns separately from Sample B, to make whatever interpretations seemed justified from these additional returns, but not to merge them with the results from Sample B.

2. WEIGHTING AND ESTIMATION PROCEDURES FOR THE PART B SURVEY

Appendix A describes in fuller detail the processing and estimation procedures used for both Samples B and 3, and discusses the adequacy of Sample B. It should be noted especially that in Sample B there were only four companies responding who had less than 50 employees, which was far too small to indicate or show anything for this size class separately. These four companies were merged with the respondents for size class 50-499 employees, but they have a very small impact in this size class. Consequently these tabulations, as a practical matter, should be interpreted as representing companies with 50 or more employees. In the unweighted tabulations even the companies with 50 to 499 employees have no practical impact, but in the weighted tabulations such companies are, in fact, represented in proportion to the aggregate employment of the size class.

Both weighted and unweighted estimates are presented for part B survey results. The weighted estimates are an attempt to make estimates that represent all manufacturing establishments. The weighted estimates for a particular item were computed as illustrated by the following:

The estimated sales for the year 1969 for the SIC-product group, reported in class intervals in question b of form B, were interpreted as having the following values:

Reported:	*Interpreted value*
Up to $1 million	$300,000
Over $1 million to $5 million	1,800,000
Over $5 million to $10 million	6,000,000
Over $10 million to $25 million	13,000,000
Over $25 million to $50 million	30,000,000
Over $50 million to $100 million	60,000,000
Over $100 million to $250 million	130,000,000
Over $250 million to $500 million	300,000,000
Over $500 million to $1 billion	600,000,000
Over $1 billion	3,000,000,000

The total value of materials as a percent of the total value of sales for the year 1969 was reported in question c. Let c represent the ratio of value of materials to sales (as reported in ques. c). Then the total value added in dollars for a particular form B is equal to (1-c) times the value of sales.

The cost of metrication is reported as a percent of sales in question d. The estimated cost of metrication in dollars is obtained by multiplying, for each form B, the proportion reported in item d by the sales value.

A weight is then assigned to each return (and to the dollars associated with the return for cost of metrication and for value added by manufacture) derived as follows:

First an initial weight was computed. In determining the initial weights only the principal form B returns were used—the one for the largest SIC product group for a company that reported on two or more forms B. To obtain the initial weight the principal form B returns were divided into nine weight groups (see table A-7 in app. A) based on the original SIC categories, and also based in part on employment size class and on the response to question 5 of form A; that is, whether or not the respondent is a metric user. The initial weight for a weight group was computed as the ratio of the estimated total employment from the part A survey for all companies classified in that weight group to the total employment reported on the principal form B returns classified in that weight group. The initial weight for a company was assigned to each form B (not just to the principal form B return) received from that company.

The initial weight was then adjusted to the final weight used in the tabulations. The final weight was obtained by first computing weighted estimates of value added by manufacture from the part B survey for the three SIC categories A, B, and C, by using the initial weights, and by using all the returns from all companies. Next, the 1967 *Census of Manufactures* figures on value added by manufacture were obtained for the same three categories. The revised weights were then obtained by adjusting the initial weight for a form B by the ratio of the value added by manufacture from the 1967 *Census* to the value added estimate from the part B survey for the SIC category in which the particular form B return was classified. The method of obtaining the weights provided aggregate estimates from the form B returns that agree with the *Census of Manufactures* on total value added, and that agree approximately for the three SIC categories. This differs from the treatment of the part A survey results, where the returns were weighted to represent the universe of manufacturing companies (not manufacturing establishments) from which the sample was drawn, and with no imputation for the part of manufacturing not represented in the survey. Such imputation is implied in the part B survey results after the weighting to the level of value added for all manufacturing establishments. The difference in treatment in this respect presumably does not have an important impact on the results concerning metrication. The expansion for the part B survey to value added for all manufacturing establishments was partly a matter of convenience—value added was available in the part B questionnaire and not in the part A questionnaire. Also, value added by manufacture was available from the *Census of Manufactures*[3] for all manufacturing establishments, by industry, but not by employee size class of company.

The estimated cost of metrication to the manufacturing sector as a proportion of value added is obtained as the ratio of the weighted estimated cost of metrication to the weighted estimated value added by manufacture.

Other weighted estimates were prepared through minor modifications of this procedure appropriate to the particular item being estimated.

Unweighted estimates have been prepared by converting the items reported as percentages of sales to dollar amounts, as above, and then aggregating the total amounts as indicated by the estimate, without weighting.

The estimates from Sample 3 have been prepared in a manner similar to the procedures described for Sample B.

3. THE RESULTS OF THE PART B SURVEY

The summary estimates based on Samples B and 3 are presented in tables II-15 and II-16. More detailed results for Sample B are presented in tables II-17 through II-22. (The tables appear at the end of this section.)

a. Total Cost of Metrication—Each Company Using Its Optimum Time Period. A rough estimate of the total cost of introducing the metric system for the manufacturing sector, under a metrication program that assumes each company will adopt its optimum period for accomplishing metrication, is $25 billion in 1969 dollars. It should be emphasized that this is the estimated accumulated cost over a period of years. This estimated total cost of metrication is 8 1/2 percent of the value added by manufacture for the year 1969. It was obtained by multiplying the value added by manufacture in 1967 times the cost of metrication as a percent of the value added by manufacture from Sample B, tables II-15 and II-16, adding the results, and then adjusting the total to an estimated level of $300 billion for value added by manufacture for 1969, instead of the level of $263 billion for value added by manufacture used in the tables. The $263 billion used in the tables is from the latest (1967) *Census of Manufactures*. The $300 billion used here for value added is a rounded projection to 1969 made for this purpose and guided by the 1967 Census results and 1968 preliminary estimates.

The sample for the part B estimates is a judgment sample for which it is not possible to compute valid estimates of sampling errors of the estimates prepared from the sample. It is possible, nevertheless, to compute a sampling error that would be valid under the assumption that the sample was selected at random within certain groups. This sampling error has been computed only for the total estimated cost of metrication, and for this cost as a percent of value added by manufacture. This computed sampling error (standard error) is 13 percent of either of the two estimates. It does not reflect the effect of any systematic bias that may have been introduced in the selection of the part B samples. As indicated in appendix A, steps were taken to evaluate Sample B, and an effort was made in preparing the estimates from the sample to hold such possible biases to a low level, but we have no basis for adequately assessing the success of this effort.

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[3] *1967 Census of Manufactures*, Summary Series, General Statistics for Industry Groups and Industries, U.S. Department of Commerce, Bureau of the Census.

It is seen from tables II-15 and II-16 that the estimated cost of metrication from Sample 3 for the part B survey (described earlier) is somewhat higher than the estimated cost from Sample B. However, it appears that if Sample 3 had been merged into Sample B the principal results and conclusions would not have been greatly different from those from the Sample B actually used. We present Sample 3 results without further analysis in tables II-15 and II-16, but base our analysis and comments on the results of Sample B. This seems to be the proper course for the reasons given earlier (ch. II, sec. F, 1 above).

This estimated cost of metrication as a percentage of value added was 13 1/2 percent for manufacturers of standard parts or standard materials, and 8 percent for manufacturers of all other products. The production of standard parts and materials constitutes only a small fraction of the total manufacturing activity.

For the manufacturers of products other than standard parts and materials, the following is an analysis of the variations among manufacturers by type of product produced and by size of company.

Type of manufacturing company	*Cost of metrication as percent of value added for 1969*
All manufacturing companies	8
Companies classified by principal type of product:	
SIC Category A. Companies producing assembled manufactured products such as automobiles, aircraft, appliances, and other machinery and equipment	11
SIC Category B. Companies producing other measurement-sensitive products such as steel and other rolling-mill products, metal cans, bearings, fasteners, screw machine products, paper and lumber	15
SIC Category C. Companies producing products that are less measurement-sensitive. Examples are cutlery, leather, rubber, furniture, jewelry	3
Companies classified by size in terms of total company employment:	
Companies with less than 500 employees (as a practical matter this can be interpreted as representing only companies with 50 to 500 employees)	16
Companies with 500–2499 employees	15
Companies with 2500 or more employees	6½

It is doubtful if the difference in the percentages shown for SIC categories A and B is of any real significance because of the large sampling variability involved, but the percentage for SIC category C is apparently considerably lower than for categories A and B. For size classes the same general comment holds—there is evidence that the cost of metrication is a smaller percentage of value added for the very large companies than for the medium and small-sized companies.

The individual manufacturers reported a wide range of estimates of the total cost of metrication, as shown in table II-19 (for manufacturers reporting in sec. 1 of form B) and in table II-22 (for manufacturers reporting in sec. 2 of form B). The distributions of total costs (when each company uses its optimum period for transition to the metric system) as a percent of 1969 value added by manufacture for the individual companies can be summarized from these two tables as follows:

Cost of metrication as percent of value added by manufacture (percent interval):	*Percent of estimated value added for companies included in the indicated percent interval*
Less than 5	52
5–9	26
10–14	7
15–19	5
20–49	9
50–99	1
100 or more	0
Total	100

This distribution covers both manufacturers of standard parts and materials, and manufacturers of other products. It is derived by combining the distributions presented in tables II-19 and II-22, with each given its appropriate weight. Some manufacturers did report in the percent cost interval 100 or more percent, but the weighted value added for such manufacturers is so small that the estimated percent rounds to zero when reported to the nearest percent.

The optimum number of years in which transition for the product group from customary units to metric units can be accomplished at minimum cost to each company is reported in form B. The optimum time period is normally the period during which the product is substantially redesigned. The average of the reported optimum time periods for transition to the metric system is about 9 1/2 years. The distribution of reported optimum years is as follows:

Optimum years (time interval):	*Percent of estimated value added for companies included in the indicated time interval*
0–4	7
5	19
6–9	13
10	43
11–14	4
15–19	11
20 or more	3
Total	100

The optimum number of years is 10 years or less for 82 percent of the estimated value added by manufacture of companies that are not producers of standard parts or materials. The question of optimum interval relates only to the companies that are not primarily producers of standard parts or materials. Companies that are producers of standard parts or materials must adjust to the time periods for the companies using their products and their cost estimates allow for this fact.

The distribution of costs of transition to the metric system among various elements of cost was requested in form B and is reported in tables II-15 through II-18. Manufacturing and quality control costs average considerably higher than the other costs, and account for nearly half of the total. About a fifth of the total is for engineering, research, and documentation costs. Personnel education costs and warehousing costs are each estimated at roughly 10 percent of the total, with the remaining items listed accounting for only small fractions of the total cost.

b. Cost of Metrication – Transition in a 10-Year Period. In addition to estimating the cost of transition to the metric system over an optimum time period, each company reporting in section 1 of form B was asked to estimate the cost of converting the specified SIC product group during a coordinated national program of metrication of 10-year duration. The results appear in tables II-15, II-17, and II-18. In summary, estimated costs for all companies were about 10 percent higher for transition under a voluntary program in a 10-year period, as compared with transition under a voluntary program with each company choosing its optimum time period. This question is, again, related only to producers of products other than standard parts and materials.

c. Annual Cost to Producers of Standard Parts or Materials to Maintain Metrication Capability. The cost reported earlier, as it related to the producers of standard parts or materials, was the cost for development of the capability to supply standard parts or standard materials to both customary standards and metric standards as metric standards are developed. Question e in section 2 of form B was concerned, in addition, with the estimated *annual* net added cost for maintaining the capability to supply standard parts or materials to both customary standards and metric standards. This estimated annual cost was 3 percent of the estimated value added by manufacture for producers of standard parts and materials, or very roughly, about one-half billion dollars per year during a period of transition. Over the transition period this might accumulate to a total of about $5 billion. Undoubtedly, the possible sampling error of this estimate is large.

d. Tangible Savings from Transition to the Metric System. All companies reporting on form B were asked: "Do you believe that significant tangible savings by your company would eventually result from a transition to the metric system of this product group?" Those responding Yes were asked, in addition, "How many years do you believe it would take these tangible savings to equal the net added cost that would be incurred by your company under transition to the metric system for this product group?"

Again, the responses for the various types of companies are shown in the tables. In summary, about a fourth of the companies responded that they would expect significant tangible savings, and for these it would take between 12 and 15 years, on the average, to achieve savings equal to the net added cost that would be incurred during the period of transition to the metric system. It is difficult to convert these to aggregate total estimates. It would appear reasonable to assume that after the transition those who reported no tangible savings would, in any event, have no added costs. Perhaps a rough speculative approach is to assume that it takes 12-15 years to recover roughly a fourth of $25 billion (because a fourth of the companies estimate savings). This translates to estimated tangible savings of roughly a half billion dollars a year, for a converted system, at the level of 1969 activity and dollars. Less tangible savings not covered by this estimate might be a more important factor. This estimate is highly speculative, must be interpreted as exceedingly rough, but may be a plausible interpretation of the results reported on significant tangible savings.

e. Sampling and Other Errors in the Cost and Time Estimates. A rough measure of the general magnitude of sampling error was reported earlier for the estimated total cost of transition to the metric system, based on the assumption (not, in fact, supportable) that the companies responding within certain classes represented simple random samples within those classes. The sampling errors, on a similar assumption, for subclasses such as SIC categories or size groups will, of course, be larger, and quite large for some of the detailed results presented in the tables. Because of the nature of the sample, as well as its size, all of the results from the part B survey need to be interpreted with considerable caution.

The estimates of the costs and benefits of transition to a metric system are subject to errors in forecasting future costs and benefits as well as to errors arising from the use of a sample. Errors in estimating future costs and benefits will necessarily arise even though extensive efforts were made by the cooperating companies to prepare reasonably accurate forecasts of the costs and benefits involved, and even though the companies have carefully attempted to follow the guidelines provided to them. We have no basis for arriving at a firm judgment as to the impact of such errors. However, there is a general tendency in planning and budgeting to avoid overestimating income or benefits, and to avoid underestimating costs. On this basis it seems reasonable to speculate that a forecast of costs of transition would be estimated conservatively, in the sense that in the judgment of the responding company they would not be underestimated. Similarly, it seems reasonable to speculate that the benefits in terms of tangible savings from the introduction of the metric system may be estimated conservatively, also, in the sense that the potential benefits are not overestimated. We have no basis for evaluating the survey results in this regard, but it would seem, as a judgment, that the net impact could reasonably be that benefits could be greater in relation to costs than would be elicited in a survey of this type. If this were true it would be consistent with experience observed in some other statistical surveys that involve estimating income and costs that are not matters of record.

Table II–15. Weighted and unweighted estimates[1] of cost, optimum time, and other items from the part B survey, covering all industries reporting on section 1 of form B (that is, covering SIC product groups other than standard parts and/or standard materials). Estimates from Sample B, and also from Sample 3.

Item	Sample B results		Sample 3 results	
	Weighted	Unweighted	Weighted	Unweighted
Value added by manufacture (1967):				
Millions of dollars	246,100	28,988	233,100	987
Number of responses	(135)	(135)	(91)	(91)
Cost of metrication, optimum period:				
Percent of value added	8.2	8.7	9.4	10.7
Based on ( ) responses	(135)	(135)	(91)	(91)
Sample size of products used for estimating cost of metrication:				
Percent of 1969 sales	28	36	49	51
Based on ( ) responses	(38)	(38)	(26)	(26)
Optimum number of years	9.4	11	7.5	8.5
Based on ( ) responses	(131)	(131)	(76)	(76)
Percent of metrication cost attributed to:				
1. Personnel Education	11	8	20	20
2. Eng., Res., and Documentation	22	21	16	18
3. Manufacturing and QC	44	46	26	25
4. Records and Accounting	5	4	7	6
5. Standards Assn. Activity	2	2	4	4
6. Warehousing	10	14	5	5
7. Sales and Service	4	3	15	13
8. Other	2	2	7	9
Total	100	100	100	100
Based on ( ) responses	(131)	(131)	(71)	(71)
Cost of metrication, 10-year period:				
Percent of value added	9.0	10.4	10.5	11.7
Based on ( ) responses	(131)	(131)	(91)	(91)
Do you expect tangible savings by your company from metrication?				
Percent responding "yes"	23	25	22	36
Based on ( ) responses	(132)	(132)	(91)	(91)
If yes, how many years to equal added cost?				
Number of years	14	11	14	17
Based on ( ) responses	(28)	(28)	(24)	(24)

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[1] The estimates are briefly described in the accompanying text and more fully in app. A.

Table II–16. Weighted and unweighted estimates[1] of cost and other items from the part B survey, covering all industries reporting on section 2 of form B (that is, covering SIC product groups that are standard parts and/or standard materials). Estimates from Sample B, and also from Sample 3.

Item	Sample B results		Sample 3 results	
	Weighted	Unweighted	Weighted	Unweighted
Value added by manufacture (1967):				
Millions of dollars	17,100	1,186	28,380	126
Based on ( ) responses	(28)	(28)	(15)	(15)
Cost of developing metrication capability (item d):				
Percent of value added	13.6	14.3	17.3	23.8
Based on ( ) responses	(28)	(28)	(15)	(15)
Estimated annual cost to maintain capability (item e):				
Percent of value added	3.3	3.5	15.6	16.2
Based on ( ) responses	(27)	(27)	(15)	(15)
Sample size of products used for estimating cost of metrication:				
Percent of 1969 sales	39	17	68	24
Based on ( ) responses	(6)	(6)	(4)	(4)
Percent of item d attributed to:				
1. Personnel Education	8	8	5	3
2. Eng., Res., and Documentation	26	24	23	25
3. Manufacturing and QC	50	52	27	23
4. Records and Accounting	4	6	8	5
5. Standards Assn. Activity	2	2	1	1
6. Warehousing	7	5	18	23
7. Sales and Service	2	2	15	19
8. Other	1	1	3	1
Total	100	100	100	100
Based on ( ) responses	(27)	(27)	(12)	(12)
Percent of item e attributed to:				
1. Personnel Education	9	6	3	3
2. Eng., Res., and Documentation	24	14	9	14
3. Manufacturing and QC	37	39	7	12
4. Records and Accounting	4	6	12	7
5. Standards Assn. Activity	2	1	1	1
6. Warehousing	16	25	19	33
7. Sales and Service	5	7	49	30
8. Other	3	2	0	0
Total	100	100	100	100
Based on ( ) responses	(24)	(24)	(11)	(11)
Do you expect tangible savings by your company from metrication?				
Percent responding "yes"	33	25	22	31
Based on ( ) responses	(28)	(28)	(15)	(15)
If yes, how many years to equal added cost:				
Number of years	13	14	7	9
Based on ( ) responses	(7)	(7)	(6)	(6)

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[1] The estimates are described briefly in the accompanying text and more fully in app. A.

Table II-17. Weighted estimates[1] of cost, optimum time, and other items from the part B survey, by SIC category, on industries reporting on section 1 of form B (that is, covering SIC product groups other than standard parts and/or standard materials). Estimates from Sample B.

Item	Total	SIC category		
		A	B	C
Value added by manufacture (1967):				
Millions of dollars	246,100	65,200	60,600	120,200
Based on ( ) responses	(135)	(76)	(34)	(25)
Cost of metrication, optimum period:				
Percent of value added	8.2	10.9	14.7	3.3
Based on ( ) responses	(135)	(76)	(34)	(25)
Sample size of products used for estimating cost of metrication:				
Percent of 1969 sales	28	25	68	20
Based on ( ) responses	(38)	(22)	(11)	(5)
Optimum number of years	9.4	12	9.5	8.0
Based on ( ) responses	(131)	(74)	(33)	(24)
Percent of metrication cost attributed to:				
1. Personnel Education	11	8	12	11
2. Eng., Res., and Documentation	22	20	26	17
3. Manufacturing and QC	44	51	35	54
4. Records and Accounting	5	3	5	8
5. Standards Assn. Activity	2	2	2	2
6. Warehousing	10	10	11	4
7. Sales and Service	4	4	6	2
8. Other	2	2	3	2
Total	100	100	100	100
Based on ( ) responses	(131)	(73)	(34)	(24)
Cost of metrication, 10-year period:				
Percent of value added	9.0	13.0	16.0	3.7
Based on ( ) responses	(131)	(73)	(34)	(24)
Do you expect tangible savings by your company from metrication?				
Percent responding "yes"	23	32	55	2
Based on ( ) responses	(132)	(75)	(34)	(23)
If yes, how many years to equal added cost?				
Number of years	14	17	9	29
Based on ( ) responses	(28)	(18)	(9)	(1)

[1] The estimates are described briefly in the accompanying text and more fully in app. A.

Table II–18. Weighted estimates[1] of cost, optimum time, and other items from the part B survey, by employment size class, of industries reporting on section 1 of form B (that is, covering SIC product groups other than standard parts and/or standard materials). Estimates from Sample B.

Item	Total	Employment size class		
		−500	500–2,499	2,500 +
Value added by manufacture (1967):				
Millions of dollars	246,100	23,800	17,000	205,300
Based on ( ) responses	(135)	(27)	(31)	(77)
Cost of metrication, optimum period:				
Percent of value added	8.2	16.2	15.3	6.5
Based on ( ) responses	(135)	(27)	(31)	(77)
Sample size of products used for estimating cost of metrication:				
Percent of 1969 sales	28	39	66	27
Based on ( ) responses	(38)	(7)	(7)	(24)
Optimum number of years	9.4	9.3	9.9	9.4
Based on ( ) responses	(131)	(26)	(30)	(75)
Percent of metrication cost attributed to:				
1. Personnel Education	11	10	13	10
2. Eng., Res., and Documentation	22	24	32	20
3. Manufacturing and QC	44	42	29	48
4. Records and Accounting	5	6	5	5
5. Standards Assn. Activity	2	2	3	2
6. Warehousing	10	8	10	10
7. Sales and Service	4	6	6	3
8. Other	2	2	2	2
Total	100	100	100	100
Based on ( ) responses	(131)	(26)	(31)	(74)
Cost of metrication, 10-year period:				
Percent of value added	9.0	16.9	16.3	7.5
Based on ( ) responses	(131)	(27)	(31)	(73)
Do you expect tangible savings by your company from metrication?				
Percent responding "yes"	23	17	84	15
Based on ( ) responses	(132)	(26)	(31)	(75)
If yes, how many years to equal added cost?				
Number of years	14	11	8.6	14
Based on ( ) responses	(28)	(7)	(10)	(11)

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[1] The estimates are described briefly in the accompanying text and more fully in app. A.

Table II–19. Estimated weighted and unweighted[1] distributions of cost of metrication as percent of value added by manufacture for optimum time period for each company (based on form B, sec. 1, ques. b, c and d). The distributions are for individual form B reports covering SIC product groups other than standard parts and/or standard materials.

Cost of metrication as percent of value added by manufacture (% cost interval)	Weighted				Unweighted all companies
	All companies	By SIC category			
		A	B	C	
0–1	17	4	5	30	12
2	28	19	3	46	21
3	3	4	4	3	3
4	4	13	......	......	14
5	6	3	17	1	2
6–9	22	28	41	8	26
10	4	0	......	8	2
11–14	3	1	4	4	2
15–19	4	14	3	......	12
20–49	8	12	21	0	5
50–99	1	2	1	......	1
100+	0	0	1	......	0
Totals	100	100	100	100	100
Based on ( ) responses	(135)	(76)	(34)	(25)	(135)

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[1] The estimates are described in app. A. The weighted results are an approximate interpretation of what the results would have shown if all manufacturing companies had responded. The unweighted results, in effect, are representative of the very large companies. The percentages are percentages of total value added accounted for in each indicated percent cost interval.

Table II–20. Estimated weighted and unweighted[1] distributions of cost of metrication as percent of value added by manufacture, for 10-year period for each company (based on form B, sec. 1, ques. b, c and h). The distributions are for individual form B reports covering SIC product groups other than standard parts and/or standard materials.

Cost of metrication as percent of value added by manufacture (% cost interval)	Weighted				Unweighted all companies
	All companies	By SIC category			
		A	B	C	
0–1	17	4	4	30	13
2	18	23	4	22	17
3	15	5	4	26	10
4	1	1		1	1
5	7	4	14	4	3
6–9	21	29	44	5	31
10	4	0		8	2
11–14	3	3	2	4	2
15–19	4	16	4		14
20–49	6	10	13	0	2
50–99	4	5	10		5
100	0	0	1		0
Totals	100	100	100	100	100
Based on ( ) responses	(131)	(73)	(34)	(24)	(131)

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[1] The estimates are described in app. A. The weighted results are an approximate interpretation of what the results would have shown if all manufacturing companies had responded. The unweighted results, in effect, are representative of the very large companies. The percentages are percentages of total value added accounted for in each indicated percent cost interval.

Table II–21. Estimated weighted and unweighted[1] distributions of reported optimum number of years for metrication (based on form B, sec. 1, ques. f, b and c). The distributions are for individual form B reports covering SIC product groups other than standard parts and/or standard materials.

Optimum number of years for metrication (time interval)	Weighted				Unweighted all companies
	All companies	By SIC category			
		A	B	C	
0–1	2	1	......	4	1
2	2	0	0	3	1
3	2	......	......	3	1
4	1	......	4	1	0
5	19	3	4	35	9
6–9	13	7	45	......	15
10	43	42	32	50	43
11–14	4	12	3	......	5
15–19	11	27	10	4	21
20–49	3	8	2	......	4
50–99	......	......	......	......	......
100+	......	......	......	......	......
Totals	100	100	100	100	100
Based on ( ) responses	(131)	(74)	(33)	(24)	(131)

[1] The estimates are described in app. A. The weighted results are an approximate interpretation of what the results would have shown if all manufacturing companies had responded. The unweighted results, in effect, are representative of the very large companies. The percentages are percentages of total value added accounted for in each indicated time interval.

Table II–22. Estimated weighted and unweighted[1] distributions of cost of developing metrication capability as percent of value added by manufacture (based on form B, sec. 2, ques. d, e, b and c). The distributions are for individual form B reports covering SIC product groups that are standard parts and/or standard materials.

Cost of metrication as percent of value added by manufacture (% cost interval)	Distribution of cost of developing metrication capability		Distribution of annual cost to maintain metrication capability	
	Weighted	Unweighted	Weighted	Unweighted
0–1	8	2	48	50
2	31	42	30	32
3	10	4		
4	2	3		
5			1	4
6–9	1	1	19	8
10				
11–14	13	10	0	1
15–19	12	5		
20–49	18	31	2	5
50–99	5	2		
100+				
Totals	100	100	100	100
Based on ( ) responses	(28)	(28)	(27)	(27)

[1] The estimates are described in app. A. The weighted results are an approximate interpretation of what the results would have shown if all manufacturing companies had responded. The unweighted results, in effect, are representative of the very large companies. The percentages are percentages of total value added accounted for in each indicated percent cost interval.

Appendix A

SAMPLE SELECTION, ESTIMATION, AND VARIANCES

1. BASIC DECISIONS ON DESIGN

The manufacturing survey design was developed within the framework of several decisions that were made early in the design of the manufacturing study. Some of the background for these decisions is discussed in chapter I and will not be repeated here. In summary, the principal decisions were as follows:

a. Survey in Two Parts. The survey would consist of two parts: part A would collect general metrication information of various types that would be relatively easy to obtain, and part B would be concerned with the more difficult subject of metrication costs. The part A questionnaire, although it contained many more questions, could be filled out by a company without extensive work and study, whereas the shorter part B questionnaire could be properly responded to only through an intensive study by qualified staff and at a considerable cost to the company.

b. The Companies To Be Studied. The units for which information would be reported in the study were defined in terms of companies rather than individual manufacturing establishments. The universe to be studied consisted of companies engaged primarily in manufacturing activity, but excluded a large number of small manufacturing companies producing products for which the increased usage of metric units or standards could be expected to have relatively small impact. The excluded companies account for about 80 percent of all manufacturing companies but only about 15 percent of the total manufacturing employment.

c. The Part A Study. For the part A study the universe from which the sample was drawn was more specifically defined by the decision to use the Dun & Bradstreet list of manufacturing companies. It was assumed that the Dun & Bradstreet list was sufficiently up-to-date and complete and that its classification of companies into employment size classes and Standard Industrial Classification (SIC) industries based on the principal products was reasonably adequate for the purposes of this study. (Some evaluation that generally confirms this judgment is given later).

The manufacturing companies on the Dun & Bradstreet list were classified into four classes by size (number of employees) and into three groups by type of manufacturing industry. The four size classes were companies with 1-49, 50-499, 500-2,499 and 2,500 or more employees. The three industry groups were derived by allocating Standard Industrial Classification (SIC) codes into three *original* SIC categories as follows:

CATEGORY I:

Companies producing assembled manufactured products such as automobiles, aircraft, appliances, and other machinery and equipment.

CATEGORY II:

Companies producing other measurement-sensitive products such as steel and other rolling mill products, metal cans, bearings, fasteners, screw machine products, paper and lumber.

CATEGORY III:

Companies producing products that are less measurement-sensitive. Examples are cutlery, rubber, leather, furniture, jewelry.

This original grouping of companies by SIC categories was used for purposes of specifying the companies from which a sample would be drawn (i.e., for specifying the universe of companies to be represented in the sample) and as strata for drawing the sample. They are referred to as the original SIC categories I, II, and III. Because some revisions were made in the definition of these categories for purposes of tabulation and analysis, the revised categories are referred to simply as SIC categories A, B, and C in the tables and elsewhere. Definition and discussion of the original and revised categories are found in part B of chapter I. Refer to appendix C for a complete listing of the SIC codes that constitute SIC categories I, II, and III and A, B, and C.

The universe from which the part A sample was selected consisted of all manufacturing companies with 50 or more employees, plus those in original SIC category I having 1 to 50 employees. A few subsequent additions of large companies were made, as is explained later in 2 c.

The part A study was limited to obtaining information relative to metrication for the principal SIC product group of the company, rather than for all types of products from companies that had diversified production involving two or more SIC product groups.

The part A study was conducted by an initial mail canvass of a relatively large probability sample (about 3,800 companies) drawn from the defined universe of manufacturing companies. The returns from the mailed canvass were supplemented by a relatively small subsample of nonrespondents for which a more intensive follow-up was conducted.

d. The Part B Study. The part B forms were to be completed in accordance with the guidelines "Orientation for Company Metric Studies" prepared by the Subcommittee on Industrial Studies of the American National Standards Institute Metric Advisory Committee and returned by mail. Practically all of the companies participating in the part B study had additional guidance and consultation from the National Bureau of Standards staff working on the study.

The part B study was based on a small judgment sample of companies (over 150 companies) who were more fully informed of the nature of the study and indicated their willingness to cooperate and do the necessary subsequent work. Industrial trade associations and others interested in the study provided assistance in arranging for volunteer cooperators who would undertake to do the necessary work for the study.

The part B form was also mailed along with the part A form to the companies included in the part A sample, with the invitation to cooperate in the part B study. It was indicated in the instructions that guidelines and additional instructions would be provided by the NBS to any company that indicated an interest in cooperating in the part B study.

Subsequently, to supplement the initial part B sample, an additional very small probability sample was drawn as a subsample of 55 companies from the sample of companies included in the part A study. Extensive efforts were made to inform these companies of the study and to persuade them to cooperate by doing the necessary work and return a part B form. This small supplemental sample was introduced to provide evidence as to the extent to which cooperation in the part B study could be obtained from such a sample. If cooperation could be obtained from a sufficiently large proportion of the cases, it would provide evidence for evaluating the results obtained from the original cooperators selected for the part B study.

2. THE PART A STUDY DESIGN

a. Selection of Initial Sample. Table A-1, column 1, shows the distribution of the universe for the survey, based on the Dun & Bradstreet list, by employment size class and by original SIC categories I, II, and III. Column 2 shows the number of companies in the initial sample as mailed out for each group, and column 3 shows the initial sample after excluding the small number of questionnaires returned by the Post Office as undeliverable or out of business. The allocation of the initial sample of approximately 3,800 companies into the 10 cells of the table reflected the desire to develop information separately for each SIC category-size cell (i.e., for each SIC category within each employment size class).

The initial mailing to the sampled companies was made by the National Bureau of Standards on May 28, 1970. A reminder letter was mailed on July 10 to each company that had not responded by that time. The total number of respondents and the number of nonrespondents after the two initial mailings are shown in columns 4 and 5 of table A-1. These are referred to as "initial respondents" and "initial nonrespondents." All companies who had not responded by August 21, 1970 were regarded as nonrespondents even though some of them responded later.

b. Selection of Subsample of Initial Nonrespondents, and Intensive Follow-Up. The number of initial nonrespondents to be selected for intensive follow-up was determined separately for each of the ten cells defined by subdividing each employment size class by original SIC category. A subsample of approximately 350 companies for intensive follow-up was allocated to the ten cells in such a manner as to allow separate estimates for the employment size classes and for the SIC categories, and also separate estimates for summary results for cross-tabulations of employment size class by SIC category. The analysis that guided the allocation of the subsample to each of the cells is given in section 2 e. Column 6 of table A-1 shows the number of companies subsampled for intensive follow-up.

Table A–1. Sample selection and returns, part A.

Original employment size class	Original SIC category	Total companies in universe sampled	Initial sample		Initial respondents	Initial nonrespondents	Subsample of initial nonrespondents				Effective response rate
			Selected and mailed	Excluding P.O. returns			Selected and mailed (certified)	Responded			
								By mail	By telephone	Total	$\frac{n_{c1} + k_c n'_{c2}}{n_c}$
		N_c (1)	n_c^* (2)	n_c (3)	n_{c1} (4)	n_{c2} (5)	n''_{c2} (6)	(7)	(8)	n'_{c2} (9)	(10)
1–49	I	19,355	967	922	258	664	66	26	16	42	.735
50–499	I	3,515	351	351	149	202	40	22	11	33	.895
	II	7,762	388	383	155	228	46	34	7	41	.940
	III	21,904	365	360	127	233	33	21	6	27	.878
500–2,499	I	323	323	320	190	130	26	14	7	21	.922
	II	515	515	508	307	201	40	26	8	34	.939
	III	1,304	326	322	156	166	34	22	6	28	.919
2,500+	I	139	139	136	115	21	11	6	2	8	.963
	II	181	181	180	136	44	22	18	3	21	.989
	III	283	283	281	191	90	30	16	8	24	.936
Totals		55,281	3,838	3,763	1,784	1,979	348	205	74	279	.840

The intensive follow-up was conducted in two stages. First, a letter from the Secretary of Commerce (along with another copy of the part A questionnaire) was sent by certified mail to the subsample of initial nonrespondents requesting their cooperation. This follow-up letter was put in the mail on August 21, 1970. The mailed responses to the certified mail follow-up are shown in column 7 of table A-1. In mid-September a telephone follow-up of nonrespondents to the certified mailing was begun (by Westat staff, but calling as representatives of the NBS). For this follow-up effort the results were to be obtained on the telephone rather than simply by urging the company to fill out and return its form. Consequently, it was considered desirable to eliminate from the telephone follow-up effort some of the questions in the part A form that would be particularly difficult to communicate and get responses to by telephone. A subset of important questions to be completed in a telephone interview was jointly agreed upon by the NBS and Westat staff. These were questions that were regarded as particularly important to the survey results, and included questions 5, 5a, 6, 9, 9a, 10, 15, 16, 17, 18, and 19, to the extent that they were applicable. Refer to appendix B for the questionnaire form. The number of questionnaires completed in the telephone interviews is shown in column 8 of table A-1.

Column 9 of table A-1 shows the total of columns 7 and 8, that is, the total response obtained in the intensive follow-up, and column 10 shows the effective over-all response rate for the part A questionnaire. The figures in column 10 are obtained by the computation:

$$\text{Effective response rate for cell } c = \frac{n_{c1} + k_c n'_{c2}}{n_c}$$

This is the over-all response rate for the questions that were designated as important questions to be covered in the telephone follow-up. The over-all response rate for other questions would be somewhat lower.

The notation is as follows:

N_c = total number of companies in cell c on the Dun & Bradstreet list (i.e., the number of companies in the frame, from which the sample was selected)

n_c^* = the initial sample of companies as selected and mailed

n_c = number of companies in initial sample (excluding a small number of questionnaires returned by the Post Office as undeliverable or out of business)

n_{c1} = total initial respondents in cell c

n_{c2} = total initial nonrespondents in cell c, so that $n_c + n_{c1} = n_{c2}$

$\frac{1}{k_c} = \frac{n''_{c2}}{n_{c2}}$ is the fraction of initial nonrespondents in cell c that were drawn into the intensive follow-up sample.

n''_{c2} = number of cases in cell c drawn into the intensive follow-up sample from the n_{c2} initial nonrespondents

n'_{c2} = number of responses obtained by the intensive follow-up efforts

The effective response rate for a subtotal or for all cells combined

$$= \frac{\Sigma N_c (n_{c1} + k_c n'_{c2}) / n_c}{\Sigma N_c}$$

where the summarization is over the cells for which the total is computed. This over-all response rate was 84 percent, and indicates a relatively high rate of response in the part A survey. It was particularly high (92 to 99%) in the two larger employment size classes.

c. Weighting and Estimation for the Part A Survey. The tabulations in the study are weighted tabulations in which the returns for each original SIC category-size cell are weighted by the reciprocal of the sampling fraction for that cell.

The weights applied to the returns make it possible to produce valid estimates for the universe sample or for any desired subgroups in which there may be an interest for analytical purposes. Such subgroups need not be the particular cells used as strata in sample selection. In fact, the employment sizes used in the tabulations are those indicated by the responses on the A forms, rather than the earlier employment size classes obtained from the Dun & Bradstreet records. Similarly, as indicated earlier, the SIC categories reflected in the tabulations involve some revisions from the original SIC categories used for sample selection. Tabulations can be made for any other subclasses or aggregates as desired, although the sampling errors may be large for any subclass that involves too small a sample.

The weights used reflect the reciprocals of the sampling fractions, cell by cell. No adjustment was made in the weights for nonresponse, so that any aggregate estimates reflect the universe of respondents to the survey (including the initial respondents and the respondents to the intensive follow-up) with no imputation for nonrespondents to the intensive follow-up effort.

Specifically, the weights were obtained as follows for a particular respondent company in the survey (the particular respondent company is identified by the subscript i).

$$w_i = \frac{N_c}{n_c} \text{ if the return was for an initial respondent in cell } c.$$

$$w_i = \frac{N_c}{n_c} k_c \text{ if the return was for an initial nonrespondent in cell } c.$$

The method used in computing the weights (i.e., the exclusion of Post Office returns from n_c) makes the implicit assumption that the relatively small number of questionnaires returned by the Post Office as undeliverable or out of business would have been offset, in an up-to-date Dun & Bradstreet list, by new or other companies that would have been on a more up-to-date list and that these companies would not have responded differently from the responses obtained within the same employment size and SIC category. Since the number involved is very small and their employment even smaller this assumption will have little effect on the results and was made for convenience.

Subsequently, a small addition was made to the part A sample. A few large companies who were cooperators for the part B study and who were large enough to have been included in the A sample with certainty were found not actually to have been included in the sample, either because of some errors in the process of sample selection or because of some omissions in the universe listings. These were added to the appropriate SIC category-size cell of the A sample and given the weight of that cell. (For the cells involved the weights were almost exactly equal to unity. Because of the exclusion of the Post Office returns from n_c they were sometimes as large as 1.02.)

(1) An estimate of the percentage of some category of companies that have a specified characteristic is

$$p_g = \frac{y_g'}{x_g'} = \frac{\Sigma w_i y_i}{\Sigma w_i x_i}$$

This might be, for example, an estimate of the percent of the companies in SIC category A that would have responded to question 5 that they are now using metric measurement units or engineering standards, where x_i has the value 1 if the respondent is a member of category g (i.e., is a manufacturing company classified in SIC category A) and otherwise x_i is equal to 0, and y_i has the value 1 if the respondent is a member of category g and also replies "yes" in question 5, and y_i is 0 otherwise.

This is an estimate of the response that would have been obtained had the initial mailings and intensive follow-up been applied to all companies in the frame.

(2) In the above estimates a company is weighted by the reciprocal of the sampling fraction. Such percentages will be of interest, but for aggregates, particularly across employee size classes, such a percentage may be subject to misinterpretation because a small company counts "1" in a tally, as does a medium-sized one, or a very big one. Consequently, still another type of estimate was made to help in interpreting the results of the manufacturing survey. It would be desirable to have tabulations that weight a company's response by the importance of the company's production in terms of value added by manufacture. We do not have value added by manufacture on the form A, but can obtain a rough approximation to it by using weights based on the approximate aggregate number of employees in the company. Note that this approach will weight the response for a company by the approximate total employment of that company, even though the responses in form A relate to the principal SIC product of that company, and not to all products of that company. Nevertheless, tabulations weighted by total employment of the company in this manner will roughly reflect the importance of the value added of the principal SIC product of the company and were used for lack of a better alternative. From the *Census of Manufactures* results showing concentration of products produced within establishments and showing concentrations of establishments by SIC within companies, it appears that this approximation, while a relatively crude one, should give weights roughly in proportion to weights that would be obtained if the value added were available and used for the relevant SIC product groups.

To make estimates using weights for individual company reports in proportion to the company aggregate employment, the weight for the i^{th} establishment will be

$$u_i = w_i e_i$$

where e_i is the response obtained on form A, question 1, for that company with values for number of employees assigned as follows:

a.	10	e.	1,600
b.	100	f.	4,800
c.	350	g.	30,000
d.	700		

Then the estimated proportion of companies in some group g giving a "yes" response to question 5, with a company's response weighted by the company employment, will be

$$p_g = \frac{\Sigma u_i y_i}{\Sigma u_i x_i}$$

There will not be large differences between the estimates of p_g given in paragraphs (1) and (2) above if the estimate is for an employment size class, but the differences may be substantial where it is across size classes, as for all of SIC group A.

Both types of estimates were used in interpreting the survey results.

d. Estimation of Sampling Errors from the Part A Sample. Sampling errors can be computed from the actual survey returns for the part A sample for any desired sample estimates. Approximate variance estimates have been made as follows:

(1) The form A returns were subdivided into 10 samples.

(a) All forms for initial respondents in cells in which the original sample was selected with certainty were assigned to *each* of the 10 subsamples.

(b) All remaining *initial respondents* and *initial nonrespondents* were assigned a subsample digit (and thereby to the corresponding subsample number) on the basis of the terminal digit of the control number. Those with the control number ending in 1 were assigned to subsample 1, those with the control number ending in 2 were assigned to subsample 2, etc., with those with control number ending in 0 assigned to subsample 10. It should be noted, in this connection, that the control numbers were assigned sequentially to the initial sample when the list was ordered by original SIC category within size class.

(c) The resulting 10 subsamples were made up as follows:

Subsample 1: All forms in (a) above plus the forms for initial respondents and those for the responding subsample of initial nonrespondents in (b) that have the assigned digit 1.

Subsample 2: All forms in (a) above plus the forms for initial respondents and those for the responding subsample of initial nonrespondents in (b) that have the assigned digit 2.

Subsample 10: All forms in (a) above plus the forms for initial nonrespondents and those for the responding subsample of initial nonrespondents in (b) that have the assigned digit 0.

(2) The tabulations for which variances were to be computed were made for each of the 10 subsamples by following the estimation procedures described earlier, except that original weights were modified. In the case of those companies in group (a) the new weights are the same as the original weights (and are exactly or very close to unity); that is, $w_{si} = w_i$ where the subscript s designates the subsample or $u_{si} = u_i$. For those in group (b) the revised weights will be $w_{si} = 10\ w_i$ or $u_{si} = 10\ u_i$.

Tabulations were made for each of the 10 subsamples by using the estimation formulas given earlier and by using the designated subsample weights instead of the original weights.

(3) To estimate the variance of a sample estimate, let y_s represent any particular estimate from subsample s, such as one of the percentages defined above. Let y be the corresponding estimate from all 10 subsamples combined (made with the original weights). The estimated variance of the sample estimate, y, is then obtained by computing

$$\hat{\mathrm{Var}}\, y = \sum_{s}^{10} (y_s - y)^2/90$$

The estimated standard error of y is

$$\hat{\sigma}_y = \sqrt{\hat{\mathrm{Var}}\, y}$$

An alternate estimate (almost as efficient but very simple to compute) of the standard error of y is

$$\hat{\sigma}_y = \frac{R(y_s)}{10} \text{ where } R(y_s) \text{ is the range of the } y_s,$$

i.e., the difference between the largest and smallest of the y_s.

Estimated standard errors for various summary statistics are summarized in table II-14, chapter II.E. Standard errors for some additional statistics can be readily obtained from the results tabulated for the ten subsamples. These results by subsample have been made available in machine sheet printouts that are not included in the report.

e. Advance Speculation of Sampling Errors, and Determination of Subsample Sizes.

Rough advance speculations of the magnitudes of the sampling errors to be expected for a few summary measures are needed before actual sample results can be available from which to make variance estimates. These advance speculations are useful guides in the design of the sample and in the design of the tabulation plans.

The following analysis, which involves certain simplifying assumptions, provided the basis for such advance speculations. These speculations were made after the numbers of initial responses and initial nonresponses were known, and were used in planning the follow-up sample and the tabulations. Separate advance variance speculations were made for the three original SIC groups by the four size classes.

The estimate of the proportion of the companies in cell c having some characteristic is

$$p_c = \Sigma w_i y_i / \Sigma w_i x_i$$

An estimate of the variance of p_c will be approximately

$$\sigma^2_{p_c} = \frac{F_c p_c q_c}{n_c} + \frac{R_c^2 n_{c2}^2}{n_c^2} \frac{k_c - 1}{k_c} \frac{p_{c2} q_{c2}}{n'_{c2}}$$

where p_c, n_c, n_{c2}, n'_{c2}, and k_c are as defined earlier and R_c is the expected response rate for the subsample of initial nonrespondents in cell c.

$$q_c = 1 - p_c$$

p_{c2} is the proportion of initial nonrespondents in cell c that have the characteristic

$$q_{c2} = 1 - p_{c2}$$

$$F_c = \frac{N_c - n_c}{N_c}$$

If we assume that approximately $p_c q_c = p_{c2} q_{c2}$ this becomes

$$\sigma^2_{p_c} = \frac{p_c q_c}{n_c} \left\{ F_c + \frac{R_c n_{c2}}{n_c} (k_c - 1) \right\}$$

$$= \frac{p_c q_c}{\hat{n}_c}$$

where $\hat{n}_c = \dfrac{n_c}{F_c + (k_c - 1) R_c n_{c2} / n_c}$

is the equivalent size of a simple random sample (from a large population, or for simple random sampling with replacement) to yield the variance $\sigma^2_{p_c}$

As an example, let c designate the size class 50-499 in SIC category II. Then,

$$F_c = \frac{7762 - 383}{7762} = 0.95$$

$$n_c = 383$$

$$n_{c2} = 228$$

If we subsample initial nonrespondents at the rate of 1 in 5, and if we assume the response rate in this subsample is $R_c = .60$, we have

$$\hat{n}_c = \frac{383}{0.95 + (0.60)\,\frac{228}{383}\,(5-1)} = 160, \text{ approximately,}$$

and consequently the variance of a proportion, p_c, estimated from the sample for this class will be approximately $p_c q_c / 160$.

Table A-2 shows a set of values for $1/k_c$ (where $1/k_c$ is the fraction of initial nonrespondents in cell c that are subsampled for intensive follow-up). These values were derived by looking at the sample sizes, n_c, achieved in each of the ten classes, using the formula above with some alternative values of k_c that would yield a total intensive follow-up sample of approximately 350 companies, and adjusting the subsampling fractions to yield reasonably reliable results in each of the classes separately. It also shows approximate values for $\hat{n}_c$ for the proposed subsampling fractions for initial nonrespondents in combination with the initial responses already obtained.

The subsampling fractions as shown in table A-2 were discussed and agreed upon with the staff of the National Bureau of Standards. The subsample was drawn at these rates, and a request to respond was mailed by the National Bureau of Standards by certified mail.

f. Evaluation of the Adequacy of Coverage and Classifications of the Lists Used for Drawing the Part A Sample. The part A sample was drawn (by procedures indicated earlier) from lists of manufacturing companies obtained by the Department of Commerce from Dun & Bradstreet. The lists were obtained in April 1970, and represented the state of the lists as maintained by Dun & Bradstreet at that time. The information on employment and SIC codes on the Dun & Bradstreet lists was used in defining the universe to be covered and in selecting the sample.

It is not feasible to obtain comparable statistics from another source for adequate evaluation of the coverage of the total list of manufacturing companies obtained from Dun & Bradstreet. Dun & Bradstreet report that their list includes approximately 300,000 companies. This compares with about 275,000 manufacturing companies in 1963 as reported by the Bureau of the Census.[1] This comparison should in no sense be taken as an indication that the Dun & Bradstreet lists are the more complete. The definition of a company is somewhat illusive, in a number of respects, and not necessarily comparable between the two sources. Also the difference in time period is substantial. Some differences will arise from the classification of whether or not a company is primarily a manufacturing company. The same comparison between the Dun & Bradstreet lists and the Bureau of the Census reports can be made for companies with 500 employees or more. The Bureau of the Census *1963 Enterprise Statistics* shows 3,336 manufacturing companies

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[1] Bureau of the Census, U.S. Department of Commerce, *1963 Enterprise Statistics*, Part I (Series ES 3, No. 1), p. 172.

Table A-2. Computation of effective sample sizes ($\hat{n}_c$) by original SIC category and employment size class

Original employment size class	Original SIC category	(1) N_c number in frame	(2) n_c initial sample (excluding P.O. returns)	(3) n_{c2} initial nonresponses	(4) $\frac{1}{k_c}$ subsampling fraction	(5) Total follow-up sample $n''_{c2} = n_{c2}/k_c$	(6) F_c $\frac{N_c - n_c}{N_c}$	(7) $\frac{R_c n_{c2}}{n_c}$ (assumes $R_c = .6$)	(8) $\hat{n}_c$
1–49	I	19,355	922	664	1/10	66	.95	.432	190
50–499	I	3,515	351	202	1/5	40	.90	.346	154
	II	7,762	383	228	1/5	46	.95	.357	160
	III	21,904	360	233	1/7	33	.98	.390	108
500–2,499	I	323	320	130	1/5	26	(1)	.244	326
	II	515	508	201	1/5	40	(1)	.238	535
	III	1,304	322	166	1/5	34	.75	.312	161
2,500 +	I	139	136	21	1/2	11	(1)	.092	1,430
	II	181	180	44	1/2	22	(1)	.150	1,200
	III	283	281	90	1/3	30	(1)	.192	740
Totals		55,281	3,763	1,979		348			

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[1] These are very near zero and were treated as equal to zero in the computations.

with 500 or more employees, which number 2,745 on the Dun & Bradstreet lists; the latter is 82 percent of the Census total. Presumably, again, definitional problems and time differences will affect the comparison. The time differences can be a source of serious incomparabilities, especially in view of the extensive mergers that have been taking place among companies in the United States, and might well explain much or all of the difference. The fact that a company may not be defined uniquely may not be a particularly serious problem, since the coverage in this survey is for the principal product class for a company, and for this purpose the responses from a company presumably will not be seriously influenced by including or not including a particular subsidiary within a possible marginal classification.

The survey returns themselves provide a means for evaluating the classification for employment size and principal SIC product codes as reported on the Dun & Bradstreet lists. Table A-3 shows a comparison by employment-size class of the employment as reported on the Dun & Bradstreet lists with the employment size as reported in the survey results (based on responses to ques. 1, form A). About 85 percent of the cases fall in the same employment-size class. The three largest differences were due to reporting companies shifting to a lower size class than shown on the Dun & Bradstreet lists. This table indicates fairly good agreement, especially recognizing that there are some cases in which the concept of what is included in a company may differ in the Dun & Bradstreet report and in the company response.

Table A-3. Comparison of estimated number of companies in each employment size class based on the sizes reported on the Dun & Bradstreet list for responding companies and the responses obtained in the Survey (form A, ques. 1).[1]

	Employment based on Form A returns	Under 50	50–499	500–2,499	2,500 or more
Employment based on Dun & Bradstreet list	46,480 (Total) 46,480 (Total)	18,961	24,861	2,138	520
Under 50	14,232	13,707	525	0	0
50–499	29,666	5,248	23,891	527	0
500–2,499	1,974	0	437	1,507	30
2,500 or more	608	6	8	104	490

[1] The figures presented are weighted estimates expanded to represent all companies that would have responded had form A been mailed to all companies on the universe list and if the intensive followup had been carried through for all nonrespondents.

Table A-4 makes a similar comparison for the SIC categories, showing the estimates of the numbers of companies reported in the same or in a different SIC category when classified on the basis of the SIC codes reported on the Dun & Bradstreet lists, and when based on the response to form A, questions A and 4. This comparison shows remarkably close agreement.

The apparent agreement is much closer than it should be because the responses on form A are "loaded" in the sense that the respondents were instructed in the letter of invitation to respond to the SIC code that was shown at the top of the letter and that was printed from the Dun & Bradstreet lists. Only if the respondent took the initiative in determining that another SIC code was more appropriate, or if in the question 4 response he gave a description that was totally inconsistent with the SIC code reported in question A, was there an opportunity for a discrepancy to appear. Also the comparisons are made not for individual SIC codes but only for the very broad SIC categories so that a change that would not shift the SIC category would not be indicated as a change in table A-4. Nevertheless, we conclude that comparisons in table A-4 should be interpreted as favorable.

Table A–4. Comparison of estimated number of companies in each original SIC category based on the principal SIC codes reported on the Dun & Bradstreet list for responding companies and the response obtained in the Survey (form A, ques. A and 1).[1]

	Original SIC category based on Form A returns	I	II	III
Original SIC category based on D & B list	46,480 (Total) 46,480 (Total)	17,951	7,849	20,680
I	17,809	17,809	0	0
II	7,957	129	7,826	2
III	20,714	13	23	20,678

[1] The figures presented are weighted estimates expanded to represent all companies that would have responded had form A been mailed to all companies on the universe list and if the intensive followup had been carried through for all nonrespondents.

We conclude from the various evidence presented that, while the Dun & Bradstreet lists may contain some problems in completeness of coverage, there are relatively few problems in classification. Generally, the evidence presented supports the interpretation that the Dun & Bradstreet lists were reasonably adequate for a broadly-based study such as this one, that does not involve the development of highly accurate measures but does provide important broad indicators.

3. THE PART B STUDY DESIGN

a. Part B Samples. As indicated in section 1 of this appendix covering the basic decisions, there were three sources of sample information for the part B study. These were as follows:

(1) *Sample 1.* An initial "solicited" sample that served as the principal source of information for the part B study. Originally, cooperative arrangements were made with over 150 companies. Industrial trade

associations and other interested groups helped the NBS staff in soliciting and arranging for volunteer cooperators who were informed of the nature of the study and would undertake to do the necessary work to provide the requested information. An effort was made by the NBS staff to obtain diversification in this sample in the sense of including representation from the various company employment size classes, from the various SIC categories, and from both users and nonusers of the metric system.

Unlike the part A study, the original arrangements were made with a few of these companies to prepare a part B study on one or more SIC product groups produced by the company, so that a total of approximately 250 product group responses was expected. These did not necessarily cover all or most of the SIC product groups of the cooperating companies.

About two-thirds of the companies who agreed to cooperate actually completed the study and returned the forms in time for inclusion in the study results. The principal statistical analyses for the study were based on the returns from this sample combined with those from Sample 2, and treated as a single sample.

(2) *Sample 2.* Subsequently, an additional small probability sample of 55 companies was drawn from SIC categories I and II within the two largest employment size classes (500-2, 499 and 2,500 or more employees) and is referred to as *Sample 2* for the part B study.

Table A-5 shows the number of companies in the universe (N_c) for each of these four cells. All of these had been selected in the initial sample with certainty. Consequently, the only ones not given a chance of selection for the B sample were the very few cases returned by the Post Office as undeliverable or out of business. The number of companies in the initial sample (n_c), excluding the Post Office returns, is also shown in the table, along with the number selected for Sample 2 of the part B study. The sample was allocated to the four cells in general accordance with optimum sample principles for making estimates of the expected costs of a national metrication program. This meant including higher sampling fractions of large companies than of small ones.

The purpose of introducing this small probability sample was to determine whether or not substantial cooperation could be obtained in such a cross-section sample for the part B study, and if possible, to use the results of Sample 2 to evaluate the results obtained from Sample 1.

If substantial cooperation could be obtained, then the estimates from this small sample would help to evaluate any potential bias that might be present in Sample 1 of solicited cooperators. For example, it would be possible to argue in support of a hypothesis that the original sample of solicited cooperators might have been heavily loaded with people who strongly favored a metric system development, and thereby were active in the industry committees and arranged to have their companies included. Similarly, it would be

Table A–5. Selection of small probability sample (Sample 2) for part B study.

Employment size class and original SIC category	Number in universe sampled N_c	Initial sample (excluding Post Office returns) n_c	Number selected for part B study, sample 2
500–2,499			
I	323	320	11
II	515	508	12
2,500+			
I	139	115	16
II	181	180	16
Totals	1,158	1,123	55

possible to argue for a hypothesis that the original sample of solicited cooperators might have been heavily loaded with people who were strongly opposed to a metric system development. Strong attitudes toward a metrication program could conceivably have a strong influence on cost estimates. Other similar arguments could be developed, and could cause serious concern about the meaningfulness of the part B study if it was based on Sample 1 without further evaluation. Therefore, as stated above, if substantial cooperation could be obtained in Sample 2, the results could be used to insure against misinterpretation of the results from Sample 1 because of large bias, since, in that event, the results of the two would differ so strikingly that even such a small sample would show them up.

If, on the other hand, even with extensive efforts to obtain cooperation, substantial cooperation could *not* be obtained in the small probability sample, then the conclusion can be reasonably drawn that use of a probability sample of responses from most or all manufacturing activity was not a feasible alternative. This is, in fact, what occurred. Of the 55 companies included in the small probability sample (Sample 2) four were already cooperators in Sample 1. Of the remaining 51, cooperation was achieved from only eight companies. The efforts to obtain cooperation included an initial telephone call by responsible National Bureau of Standards personnel to the management of the company indicating the importance of the study, and urging that the company respond to the letter and questionnaire that were being put in the mail and that would outline the work to be done. The letter, dated July 30, 1970, explained the importance of the study to industry and to the nation, indicated what information was needed, and solicited their cooperation, including additional discussion with the NBS staff for guidance. The letter was followed by an additional telephone call to company representatives in an effort to answer questions and gain their cooperation.

The low cooperation rate achieved leads to the conclusion that a probability sample approach was not feasible, and that one reasonable way to do the study was the way it actually was done, that is, by soliciting and taking advantage of the companies willing to cooperate, and at the same time attempting to reasonably cover the range of employment size classes, the SIC categories, the users or nonusers (of metric measurements or standards), and those favorable toward or opposed to a metric program. (Some results to be presented shortly will indicate that this coverage of different types was reasonably accomplished.)

The low cooperation rate achieved can also be interpreted as indicating that there was no *large* proportion of the manufacturing companies who were strongly concerned about having a voice in the survey results. If they were so concerned, it seems reasonable to assume that they would cooperate, when given the opportunity and strongly urged to do so, even at some expense to the company.

On the basis of such considerations, together with the results presented in table A-6, which shows considerable diversity in the characteristics of cooperators in Sample B, it was concluded that the combined returns from cooperators in Samples 1 and 2 could be used as a reasonable basis for appraising the cost consequences of introducing a coordinated metrication program, but subject to caution in interpreting the results.

Table A-6. Distribution of sample B principal company returns by SIC category, employment size class, and whether or not users of metrication.

Employment size class	User of metrication?	SIC category			Totals
		A	B	C	
1–49	Yes	1	1	1	3
	No	0	1	0	1
50–499	Yes	5	2	1	8
	No	8	8	0	16
500–2499	Yes	5	3	1	9
	No	12	8	2	22
2500+	Yes	14	8	10	32
	No	15	15	5	35
Totals		60	46	20	126

(3) *Sample B.* Samples 1 and 2 were combined for the principal analyses of results of the part B study, and these two samples combined are referred to as *Sample B.* A summary of the distribution of these companies by employment size class (Dun & Bradstreet classes) and by SIC category is given in table A-6, with a further breakdown of the returns by the responses on form A for the compa-

ny[2] and on the basis of the company's reply to question 5 on form A. (Ques. 5 indicates whether or not the company is a user of metric measurements or standards for the principal SIC product group of the company.) It is seen that there is, in fact, a fairly good diversification of the sample among the various cells, except that there are very few cooperators in the employment size class 1-49, and relatively few in SIC category C. It is not surprising that companies in the smallest-size class (mostly with less than 20 employees) were not sufficiently concerned and willing to make a rather expensive study. Also, SIC category C included industries that tended to be less measurement-sensitive, and, again, it is not surprising to have a relatively smaller number in this class. A further analysis by the response to question 17 of form A showed that those with varying attitudes toward metrication were reasonably represented in Sample B, with about 1/6th of the cases strongly for such a program, about 1/12th strongly against, and the others either mildly for, neutral, or mildly against, with a somewhat larger number in the mildly for than in the mildly against category.

(4) *Sample 3.* It was previously indicated in section 1 of this appendix that the part B form was also mailed along with the part A form to the companies included in the part A sample, with the invitation to cooperate in the part B study. The mailed instructions requested that any of these companies that had an interest in cooperating in the part B study should communicate with the staff of the National Bureau of Standards to learn more specifically what was called for in form B, and to obtain the necessary instructions and guidance so that the studies would be carried out on a reasonably adequate and comparable basis. A few of these companies communicated with the National Bureau of Standards, were given the necessary instructions, and were included in Sample 1. Usable responses, on form B, were received from an additional approximately 100 companies, and most of these relatively soon after the initial mailing. None of these initial responding companies followed the prescribed procedure of communicating with National Bureau of Standards personnel to get additional instructions and guidance before completing form B. Therefore, there is reason to be concerned as to whether the necessary background work was done by such companies as a basis for preparing the responses on form B, and as a consequence there is reason to question the adequacy of the responses obtained for the responding companies in Sample 3. A decision was made, therefore, to tabulate these returns separately from Sample B, and to make whatever interpretations seemed justified from these additional returns, but not to merge them with the results from Samble B. Sample 3 was tabulated, in general, in a manner similar to Sample B. The National Bu-

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[2] If a company submitted two or more form B's covering two or more SIC product groups they also submitted two or more corresponding form A's for those product groups. In this event only form A for the principal SIC product group was used in this particular tabulation.

reau of Standards staff reviewed the forms of Samples B and 3 and communicated with the companies to clarify any incomplete or apparently inconsistent responses. Incomplete returns of Sample 3 were generally excluded from the tabulations.

b. Examination of the Returns for Sample B. National Bureau of Standards staff reviewed both form A's and form B's returned by Sample B companies. For those that had apparent problems, the National Bureau of Standards staff communicated with the company and attempted to clarify any questionable responses. Except for reasonably obvious situations, changes were not made in questionable responses except with the agreement of the company. Later, Westat staff made certain additional routine reviews of form B and of the interrelationship between form A and form B from the same respondent. If necessary, additional follow-up was done by the National Bureau of Standards staff.

c. Weighting and Estimation for the B Sample. Except for a small number of responses that were received from the exceedingly small sample of 55 companies in Sample 2, Sample B (a combination of Sample 1 and 2) is not a probability sample, and there is no way to prepare unbiased estimates (or estimates that we can be sure are only moderately biased) of what would have been obtained had considered responses been obtained from all members of the manufacturing population from which the sample was drawn. However, some steps were taken that should hopefully reduce the biases of the sample and perhaps keep them reasonably small for estimates prepared from Sample B.

The initial step was to tally the form A returns for Sample B (the primary return for each company if more than one return was submitted) into the cells obtained by a cross-tabulation of the SIC categories (A, B, and C), the employment-size classes as reported in form A, and whether metric users or not as reported in form A (two nonresponses to the metric user question were treated as nonusers), as shown in table A-6. The cells in table A-6 were consolidated, using judgment, in a way that retained as much homogeneity as feasible with regard to metric usage and attitudes within the consolidated groups, and still have eight or more sample returns within each of the classes so formed. The SIC categories were kept separate, and any consolidations were on the other variables. Nine groups were distinguished, referred to as weight groups, and designated by the subscript g. The weight groups are shown in table A-7. These weight groups were then used in deriving initial weights by proceeding as follows:

Let E_g' be the estimated number of employees for weight group g from the full Sample A, and e_g the number of employees (based on the 126 principal A forms) in this group for Sample B. The *initial* weight for a form B would then be

$$u_i = u_g = \frac{E_g'}{e_g} \text{ (Note: } u_i = u_g \text{ when the } i\text{th company is in weight group "g".)}$$

If the company reported on two or more form B's, all such forms are assigned to the weight group of the principal SIC product group of the com-

Table A–7. Computation of initial and final weights, by weight groups

Weight group				No. of principal company reports in B sample	E'_g= estimated total employment	e_g= Total employment, sample companies	$u_g = E'_g/e_g$	$\frac{V_\alpha}{v'_\alpha}$	$u'_g = u_g \cdot \frac{V_\alpha}{v'_\alpha}$
g	SIC category	Size class	Metric user						
1	A....	Less than 500	Yes or no	14	439,247	3,060	143.5	1.090	156.4
2		500–2499	Yes or no	17	294,010	19,100	15.4	1.090	16.8
3		2500+	Yes........	14	590,940	294,000	2.0	1.090	2.2
4		2500+	No.........	15	911,688	198,000	4.6	1.090	5.0
5	B ..	Less than 500	Yes or no	12	1,127,427	3,020	373.3	1.293	482.7
6		500–2499	Yes or no	11	794,112	14,900	53.3	1.293	68.9
7		2500+	Yes........	8	699,132	114,000	6.1	1.293	7.9
8		2500+	No.........	15	1,411,092	324,000	4.4	1.293	5.7
9	C ..	All sizes	Yes or no	20	5,119,822	329,160	15.6	0.987	15.4
		Totals...	....	126	11,387,470	1,299,240			

pany (or, in case a company did the part B study for SIC product groups other than its principal SIC product group, the principal SIC product group for which the part B study was done is determining). All principal form B's were used in computing the initial weights, including those reporting on either section 1 or section 2.

The initial weight was then adjusted to the final weight used in the tabulations. The final weight was obtained by first computing weighted estimates of value added by manufacture from the part B survey for the three SIC categories A, B, and C, by using the initial weights, and by using all the returns from all companies. Next, the 1967 *Census of Manufactures* figures on value added by manufacture were obtained for the same three categories.

The final weight u'_i, for the i^{th} form B was then obtained by adjusting the original weight

$$u'_i = u_i \frac{V_\alpha}{v'_\alpha}$$

where V_α is the value added by manufacture from the 1967 *Census of Manufactures* for SIC category $\alpha(\alpha = \text{A, B, or C})$, and

$$v'_\alpha = \{\Sigma u_i(1-c_i)b_i\}_\alpha$$

where the sum in the braces is over those form B returns that were classified in SIC category α. The b_i is the response to question b, form B, on sales; the c_i is the response to the question c, on value of materials, so that $(1-c_i)b_i$ is the reported value added by manufacture for the SIC product group on the i^{th} form B. Then v'_α is the estimated value added by manufacture for SIC category α from the part B survey based on the initial weights.

Note that all forms B were used in computing the final weights, including multiple forms from a company and including the reports on both sections 1 and 2 of form B. This method of computing the final weights provides an aggregate estimate of value added by manufacture from the form B returns that agrees, except for the effect of rounding the weights, with the total value added by manufacture reported in the 1967 *Census of Manufactures*. It will provide approximate agreement for each of the three SIC categories.[3]

Table A-7 shows the computation of the initial and final weights for the nine weight groups.

In general the weighted estimates for Sample B were then made by computing

$$x' = \Sigma u_i' x_i \text{ for an estimate of an aggregate}$$

or

$$\bar{x} = \frac{\Sigma u_i' x_i}{\Sigma u_i'} \text{ for an estimate of an average}$$

or

$$\frac{x'}{y'} = \frac{\Sigma u_i' x_i}{\Sigma u_i' y_i} \text{ for an estimate of a ratio or percentage}$$

where, for example, x_i is the cost of metrication, in dollars, and y_i is the value added by manufacture, in dollars, reported on the i^{th} form B.

The x_i is obtained from form B by computing $x_i = d_i b_i$ where d_i is the reported cost of metrication as a fraction of sales, and b_i is obtained from question b on form B by using the following conversion table:

Question b, response:	*Sales (in millions of dollars)*	Question b, response:	*Sales (in millions of dollars)*
a	0.3	f	60
b	1.8	g	130
c	6	h	300
d	13	i	600
e	30	j	3,000

The y_i was obtained in a similar manner. The tabulations were made separately for sections 1 and 2 of form B by following the estimation procedures described above.

Simple unweighted tabulations were made in parallel with the weighted tabulations, to provide information on the size of sample in each cell, and for comparison with the weighted estimates as an aid to interpretation. The unweighted tabulations were made by simply averaging or taking percentages of the individual form B results (converted to dollars where appropriate).

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[3] A minor change in the procedure would have provided exact agreement for the three SIC categories, but this involved some additional work that did not seem worthwhile when compiling the results on the very short time schedule available after including some of the late form B reports.

d. Computation of the Standard Error of the Estimated Cost of Metrication. Since the B sample was a judgment sample no valid computation can be made of the standard error of the estimated cost of metrication. We can obtain measures of the amount of variability of the reported values within the weight groups, and from this derive an indication of what the standard error would have been had the sample used actually been a simple random sample within the weight groups. Such a computation was made and provides at least some guidance for interpreting the possible range of variability in the estimated cost of metrication. It provides no information on the possible impact of any bias in the sample.

The computed sampling error, assuming a simple random sample within weight groups and independence between weight groups, was made as follows:

(1) All reports from a single company within a weight group were consolidated into company reports. Let i designate the i^{th} such report. The company report within a weight group might be a principal company report or secondary company report. It was a principal company report if it was for the principal SIC product group as covered in the part A survey, or if it was a consolidated report that included the principal SIC product group. Otherwise it was a secondary company report.

(2) For each company report (primary or secondary) compute

$$m_{gi}=\sum_j m_{gij}=\sum_j d_{gi}b_{gi}$$

where m_{gij} is the response to question d (treated as a ratio, not a percent). (Generally there will be only one form B for a company, and in this event there will be no summation over j.) If e_{gi} is the employment figure for the company obtained from the principal form B for the company (with the class interval figures interpreted as shown in 2C (2) of appendix A), and if n'_g is the number of principal company reports in weight group g, and if $n_g=n'_g+a_g$ is the total number of reports in weight group g, including the a_g secondary company reports in that weight group.

Then

$$v^2_{e_g}=\frac{\left(\sum^{n'_g} e^2_{gi}/n'_g\right)-\bar{e}^2_g}{(n'_g-1)\,\bar{e}^2_g}$$

$$\bar{e}_g=\sum^{n'_g} e_{gi}/n'_g$$

$$v^2_{m_g}=\frac{\left(\sum^{n_g} m^2_{gi}/n_g\right)-\bar{m}^2_g}{(n_g-1)\,\bar{m}^2_g}$$

$$\bar{m}_g = \sum^{n_g} m_{gi}/n_g$$

$$v_{e_g m_g} = \frac{\left(\sum^{n'_g} e_{gi} m_{gi}/n'_g\right) - \bar{e}_g \bar{m}_g}{(n_g - 1)\,\bar{e}_g \bar{m}_g}$$

$m'_\alpha = \sum_g^\alpha \sum_i^{n_g} u'_{gi}\, m_{gi}$ is the estimated total value added by manufacture in the αth SIC category A, B, or C, and u'_{gi} is the adjusted weight as derived above. It follows from the definition of u'_{gi} that

$$m'_\alpha = \sum_g^u \sum_i^{n_g} u_g m_g$$

where u_g is the initial weight for weight group g and

$$m_g = \sum^{n_g} m_{gi}$$

The estimated variance of $u_g m_g$ is approximately

$$\text{var } u_g m_g = \frac{E_g'^2 m_g^2}{e_g^2} \left(v^2_{E'_g} + v^2_{e_g} + v^2_{m_g} - 2v_{e_g m_g}\right)$$

where E'_g is the estimated total employment in weight group g from the Part A survey and $v^2_{E'g}$ is the estimated relative variance of E'_g obtained approximately from the Part A variance computations.

The estimated variance of m'_α is approximately

$$\text{var } m'_\alpha = \sum_g^\alpha \text{var } u_g m_g.$$

Let $m' = \Sigma m'_\alpha$, then the estimated variance of m' is Σ var m'_α and the estimated standard error of m' is $\hat{\sigma}_{m'} = \sqrt{\text{var } m'}$. The actual computations led to the following values:

SIC category	m'_α (\$1,000,000)	$\hat{\sigma}_{m'_\alpha}$ (\$1,000,000)	$\frac{\hat{\sigma}_{m'_\alpha}}{m'_\alpha}$
A	7,639	1,172	0.15
B	10,657	2,522	.24
C	3,993	652	.16
All	22,289	2,857	.13

ITEMS USED IN THE SURVEY

1. Secretary of Commerce letter of transmittal dated May 28, 1970 for the survey questionnaire instructions and questionnaires.
2. Letter dated July 10, 1970 sent to those not returning questionnaire (second request for response).
3. Letter dated August 21, 1970 sent to those not returning questionnaire (third request for response).
4. U.S. Metric Study – Manufacturing Survey Information and Instructions booklet.
5. U.S. Metric Study – Manufacturing Questionnaires:

   Part A – General Data (form NBS 510)
   Part B – Cost – Sections 1 and 2 (form NBS 510)

May 28, 1970

Dear Sir:

Public Law 90-472 (copy enclosed) authorizes the U.S. Metric Study and requires me to recommend to the Congress what action, if any, should be taken in the United States as a consequence of the increasing worldwide usage of the metric system.

An important sector that must be surveyed in this Study is the manufacturing industry, and we need your help in order to do this. Your response to the enclosed questionnaire will aid us in determining the implications to your industry of various hypotheses and will help me to make my recommendations to the Congress. Please note that the product group on which we ask you to report is identified by the four-digit SIC (Standard Industrial Classification) number imprinted on the first line of the address.

The enclosed questionnaire consists of two parts: Part A, which is general in nature, and Part B, which covers costs and savings. The part of our survey in which your organization has been included concerns Part A. I would appreciate receiving your response to Part A, which should require no more than a few hours to complete.

Part B has been enclosed to give you the full context of our manufacturing survey. Response to this part would involve an in-depth study of your operations. My primary request is to seek your response to Part A, but I would also be pleased to have your participation in Part B, should you desire to submit your company's data on costs and savings for our survey. If you wish to undertake Part B, further guidance may be obtained from the Manufacturing Survey Team, U.S. Metric Study, National Bureau of Standards, Washington, D.C. 20234 (Phone: 301-921-2658).

I sincerely hope that you will be able to help us by answering Part A of the questionnaire and returning it to us, preferably within the next 30 days, in the enclosed, self-addressed envelope.

Thank you in advance for your cooperation in this important effort.

Sincerely,

Secretary of Commerce

8 Enclosures

July 10, 1970

Dear Sir:

With his letter to you dated May 28, 1970, copy enclosed, Secretary of Commerce Stans forwarded to you the U.S. Metric Study Manufacturing Industry Questionnaire, Parts A and B, and requested your response to Part A, General Data.

As of this date we have not received your completed questionnaire. Because of the importance of the survey of the manufacturing industry in the study that we are conducting, we are anxious for the widest possible response to our questionnaire.

I shall deeply appreciate it if you will fill in our questionnaire, Part A, and mail it within the next 10 days in the self-addressed envelope forwarded to you with the letter of May 28 from Secretary Stans. If you need another copy of the questionnaire, please let us know.

If you have already mailed the questionnaire, please disregard this letter and accept our thanks for your cooperation.

Sincerely,

A. G. McNish, Manager
Manufacturing Industry Survey
U.S. Metric Study

Enclosure

August 21, 1970

THIRD REQUEST

Dear Sir:

We have not yet received the reply for your company to the questionnaire that will help us to determine the impact on the United States of increasing worldwide use of the metric system. An additional copy of the questionnaire is enclosed, with instructions for completing it, and we hope you can give it your early attention. The manufacturing industry is one of the sectors that will be importantly affected by increasing worldwide metric usage, and we need the returns from the small sample of companies we have selected for study in order that we shall have proper information for completing our study and for reporting the results to the Congress.

Please note that the product group on which we ask you to report is identified by the SIC (Standard Industrial Classification) number imprinted on the first line of the address.

I sincerely hope that you will be able to help us by answering the enclosed questionnaire (it is Part A of two questionnaires that are being used in the study). If you have any questions please call me (Phone: 301-921-2658).

Enclosed you will find a self-addressed, postage-paid envelope to return the completed questionnaire as soon as possible. Thank you in advance for your cooperation in this important effort.

Sincerely,

L. E. Barbrow, Acting Manager
Manufacturing Industry Survey
U.S. Metric Study

3 Enclosures

U. S. Department of Commerce
National Bureau of Standards

BoB # 41-S70016
Approval expires June 30, 1971

U.S. METRIC STUDY

(under Public Law 90-472, August 9, 1968)

MANUFACTURING INDUSTRY SURVEY

Information and Instructions

Additional information or copies of the questionnaire may be obtained from:
Manufacturing Survey Team
U. S. Metric Study
National Bureau of Standards
U. S. DEPARTMENT OF COMMERCE
Washington, D. C. 20234
Phone: (301) 921-2658

U.S. METRIC STUDY— MANUFACTURING INDUSTRY QUESTIONNAIRE

INTRODUCTION

Public Law 90-472, August 9, 1968, copy attached, authorizes the Secretary of Commerce to conduct a program of investigation, research, and survey "to determine the impact of increasing worldwide use of the metric system on the United States" and to "appraise economic . . . advantages and disadvantages of the increased use of the metric system in specific fields and the impact of such increased use on those affected".

By the time of the enactment of the Law practically all of the countries of the world had adopted the metric system of measurement, with the British Government, in 1965, announcing their intention of converting all manufacturing and other sectors of their economy to the metric system with a planned completion data of 1975 and with the South African Government in 1967 deciding to follow suit.

In 1969 the New Zealand Government announced their intention of making the metric system their national system of weights and measures and in January 1970, the Australian and the Canadian Governments announced the same intention.

The data collected in this survey will be presented in the Department of Commerce Report to Congress on an industry-wide basis and in such form that individual company data cannot be isolated.

SCOPE AND PURPOSE

The purpose of this questionnaire is to obtain information that will assist in determining what course of action with respect to metrication the United States should follow.

This questionnaire is on a Company-wide* basis for one 4-digit product group regardless of how many establishments of your company participate in the manufacture of that product group. It has two parts: Part A, which pertains to general facets of metric usage, and Part B, which deals with the subject of "added costs" that would be attributable to increased use of the metric system. Much of the information requested in Part A is conjectural rather than factual, while the data requested in Part B requires an extensive in-depth and relatively expensive internal study by the respondent. All recipients are requested to complete Part A; the completion of Part B is optional. If you plan to respond to Part B please communicate with the Manufacturing Survey Team (address and phone number on front cover page) for further background.

Your replies will be of great value in enabling the Secretary of Commerce to propose an appropriate course of action for consideration by the United States. However, the questions and assumptions do not imply what course of action may be recommended by the Secretary in his report to the Congress.

This questionnaire is based on the 4-digit Standard Industrial Classification (SIC) as defined in the Bureau of the Budget SIC Classification Manual. A separate form should be used for the group of products constituting each 4-digit SIC to be reported. If you require information regarding the products classified within each SIC industry, please consult with your Comptroller or your nearest Department of Commerce Field Office, or the U.S. Metric Study Manufacturing Survey Team (address on front cover page).

DEFINITIONS

The following definitions are applicable to Parts A and B:

(1) **Domestic production:** your production in the United States, including Puerto Rico.

(2) **Customary system:** the system of measurement units (yard, pound, second, degree Fahrenheit, and units derived from these) most commonly used in the United States. Synonyms "English system", "U.S. system". These are not to be confused with "Imperial system", which describes a related but not completely identical system currently in use in the United Kingdom and other English-speaking countries.

(3) **Metric system:** the measurement system based generally on the meter as a unit of length, the kilogram as a unit of mass, the second as a unit of time, the kelvin or the degree Celsius (formerly degree Centigrade) as a unit of temperature and units derived from these. This system has evolved over the years

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* For purposes of this survey "Company" is defined to include the parent firm and all domestic subsidiaries it owns or controls.

and the modernized version today is identified as the "International System of Units" (SI). The above units and other SI units are listed in the Annex of ISO Recommendation R 1000.

(4) **Metrication:** any act tending to increase the use of the metric system.

(5) **Engineering standard:** a practice established by authority or mutual agreement and described in a document to assure dimensional compatibility, quality of product, uniformity of evaluation procedure, or uniformity of engineering language. Examples are documents prescribing screw thread dimensions, chemical composition and mechanical properties of steel, dress sizes, safety standards for motor vehicles, methods of test for sulphur in oil, and codes for highway signs. Engineering standards may be designated in terms of the level of coordination by which they were established (e.g., company standards, industry standards, national standards).

(6) **Shop drawings:** drawings or prints with dimensions, tolerances, and other specifications from which parts are fabricated.

(7) **Research & development:** laboratory activity directed toward development of new kinds of products and processes but not immediately associated with production.

U.S. METRIC STUDY— MANUFACTURING INDUSTRY QUESTIONNAIRE

PART A—GENERAL DATA

The purpose of this Part is to obtain information as to the present impact within the United States of the increasing worldwide and domestic use of the metric system and as to the probable future advantages and disadvantages of this increasing metric usage under two assumed courses of action: (1) no coordinated action on a national scale with regard to metrication; i.e., a continuation of the present practice of using the metric system or retaining the customary system when either appears to be economically and technically preferable to the other as a matter of individual company policy, or (2) a coordinated national program of metrication based on voluntary participation involving most sectors of the economy including education.

GUIDELINES

Your attention is directed to the document titled "Orientation for Company Metric Studies" (attached hereto) prepared by the Metric Advisory Committee of the American National Standards Institute (ANSI). This document can serve as a source guide to supply you with background information and should prove of value in answering some of the questions in this Questionnaire. Other guidelines pertaining to specific questions have been included in the Instructions to those questions.

Other background materials are also attached for your information and reference. These include "ASTM Standard Metric Practice Guide", ISO Recommendation R1000", "Measuring Systems and Standards Organizations", and "The Modernized Metric System" (NBS Special Publication 304A).

Although many of the questions ask for information that is conjectural rather than factual, the acquisition of this information is necessary for the study. Furthermore, it is evident that this information as obtained from individual companies will be more reliable than if obtained from other sources. Accordingly, your best estimates are earnestly solicited.

Since precise answers to many of the questions may be difficult to develop, considered estimates will suffice in those cases.

INSTRUCTIONS

IMPORTANT. Please note that except for question 1, which solicits information as to the number of employees in your Company* in the United States, and questions 18, 19, and 21, which solicit general comments, all other questions ask for company data applicable ONLY to the 4-digit SIC product group covered by this questionnaire. If a question or a segment of a question is not applicable (NA) to your type of business indicate that fact by the notation NA, but please be careful to differentiate between the use of NA and zero.

We may wish to communicate with your company regarding some item in this report. Accordingly, please designate at the end of the questionnaire the person you wish us to contact.

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* For purposes of this survey "Company" is defined to include the parent firm and all domestic subsidiaries it owns or controls.

U.S. METRIC STUDY— MANUFACTURING INDUSTRY QUESTIONNAIRE

PART B—COST

INTRODUCTION

The purpose of this Part is to obtain information as to the costs and savings that would accrue to the manufacturing industry if the country were to follow a coordinated national program of metrication based on voluntary participation involving most sectors of the economy, including education.

The data collected in this survey will be presented in the Department of Commerce Report to Congress on an industry-wide basis and in such form that individual company data cannot be isolated.

THIS COST QUESTIONNAIRE APPLIES TO YOUR DOMESTIC PRODUCTION ONLY

The attention of respondents is directed to "Orientation for Company Metric Studies" (attached hereto) prepared by the Metric Advisory Committee of the American National Standards Institute (ANSI) to establish a basis for estimating added costs on an optimum schedule.

Other background materials are also attached for your information and reference. These include "ASTM Standard Metric Practice Guide", "ISO Recommendation R1000", "Measuring Systems and Standards Organizations", and "The Modernized Metric System" (NBS Special Publication 304A).

Please note that this Part of the Manufacturing Industry questionnaire is designed to report your in-house added cost only on a company basis.

DEFINITIONS

"Added cost" due to increased use of the metric system in a new or redesigned product is the increment of cost directly attributable to the use of the metric system over and above what the cost would have been had the new or redesigned product been designed and manufactured by using customary units.

"Net added cost" of metrication is added cost as defined above decreased by the savings during the transition period that accrue as a result of the use of the metric system rather than the customary system.

"Value of sales" represents net selling values, F.O.B. plant, after discounts and allowances and excluding freight charges and excise taxes.

"Value of materials" as used in this questionnaire includes cost of purchased materials and parts, including standard parts and standard materials incorporated in the finished product (whether purchased or produced in-house), supplies, fuel, and electrical energy.

"Standard parts" are parts for which standards have been established on a national basis. These parts are interchangeable and normally can be purchased "off-the-shelf"; such as nuts, bolts, tires, sparkplugs, lamps, vacuum tubes, electric motors, and bearings.

"Standard materials" are sheet, plate, wire, bar stock, etc. manufactured to specified thicknesses, cross-sections, and shapes established on a national basis. These materials can normally be purchased "off-the-shelf".

"Optimum period" is that period of time in which the transition of the product from customary units to metric units can be accomplished at minimum cost to your company; it is normally the period during which the product is substantially redesigned.

ASSUMPTIONS

The assumptions stated herein are for the purpose of estimating "added cost" during the transition period for converting to metric production under a coordinated national program of metrication based on voluntary participation. They do not imply what course of action may be recommended or what course of action the country may follow after completion of the study.

Assume that:

1. The use of metric units and metric engineering standards will be increased only for new or redesigned products or new or redesigned parts of the product. Unless there are distinct advantages in changing, the production of an existing item will remain unchanged un-

til the normal design life cycle of that product is completed and a new metric-designed product replaces it.

2. In-house designed products or components will be designed in metric units on a schedule that is compatible with normal obsolescence of tooling or with economically feasible conversion of tooling from customary to metric units. Existing items of production equipment will be used until their normal life cycles are completed. The only changes or conversion to metric units will be in dials, gages, some feed-rate controls and indicating devices. Such changes will be made on an economic basis, (i.e. when the demand for metric designed parts or products requires a change).

3. Out-of-house production materials and components based on metric engineering standards will become available during the transition period at no substantial increase in cost.

4. Costs resulting from mating metric components with carry-over existing customary components at their interface are added costs.

5. The transition period will be the "optimum period" for most companies. However, for companies that produce product groups that are standard parts and/or standard materials, the transition period is not an "optimum period" but is a period that is dictated by the demands of the customers.

6. The metric system will be taught in all U. S. schools during the transition period and the general public will concurrently be gaining familiarity with this system of measurement.

GENERAL INSTRUCTIONS

All elements of your manufacturing process, for the SIC product group reported on, should be investigated and any identifiable added costs associated with each element resulting from adoption of metric usage instead of customary usage should be noted.

There are two alternative Part B (blue) questionnaires. The one headed "Section 1" is for use by most companies. However, if this response covers a product group that comprises standard parts and/or standard materials, use the one headed "Section 2".

The list of areas of investigation that follows is identical with the list in item g. of both Sections of the questionnaire. Respondents are requested to consolidate the added costs determined for all elements into the applicable listed areas of investigation of item g.

In some of the areas such as "Engineering & Research" or "Records & Accounting," there may be savings of a continuing nature that would start to be realized during the transition period. To the extent practicable, any such savings during the transition period should be computed and a net cost determined. In some cases, such net costs may be negative (i.e. where savings exceed costs).

The areas to be studied include:

1. Personnel Education
2. Engineering & Research & Associated Documentation
3. Manufacturing & Quality Control
4. Records & Accounting
5. Standards Association Activity
6. Warehousing
7. Sales & Services
8. Other

Guidelines for those areas of study follow:

1. Only those workers who will be affected by the introduction of metric units will need training. In some cases, a short briefing or orientation is all that is necessary; in others, more detailed and formal instructions may be required.

2. a. What changes in engineering drawings over and above normal redesign changes, if any, will be necessary. What are the associated costs? What about new metric rulers, tables, handbooks, etc?

b. In your research department, determine what equipment will need new dials or changed indicators; what new test equipment, such as gage blocks and other metric standard devices, will need to be purchased, etc?

3. a. What existing production equipment needs new or modified dials, verniers, indicators, and the like, to read out in metric units? Will any production equipment actually need replacement of feed-screws and what are the costs of replacement? In the latter case it may prove more economical to modify the feed-screw indicator to metric readings. Which precision machine tools will need optical position indicators in metric and which will need metric digital readout? Machines on which the feed rate is dependent on the pitch of the feed-screw, such as milling machines, require special in-

vestigation. In some cases, the lead-screw drive arrangement may need to be changed. It is assumed that when a modification is expensive, it would be applied only in machines whose life before obsolescence is long.

b. What calipers, micrometers, and other tools that are furnished by your company will need to be replaced?

c. A review of the equipment used in quality control and the testing of the finished product should be made. Any added costs in changing dials, gages, etc., or even the replacement of certain equipment that cannot be changed to metric readout should be noted.

4. Included in this category are records, bookkeeping, billing, and other associated paperwork.

5. Added costs resulting from increased activity on standards organizations should be included. However, the added costs for the development of company standards will be covered in whichever department has that responsibility (e.g. Engineering or Design).

6. Added costs may accrue because of the necessity of additional inventories. These should be determined for the transition period.

7. Added costs in connection with sales, such as sales catalogues, service and replacement parts, advertising, and the like should be estimated.

8. Other elements peculiar to your operations will occur to you during your investigations. These should be noted and any added costs determined.

A different form should be used for each 4-digit SIC Product Group that you report. For small companies this will be the principal SIC product group only but other SIC product groups may be included with it if it is not practicable to sever them. Added costs should be evaluated as the total dollar added costs occurring over the transition period, based on 1969 dollars, for the SIC product group produced by your company. Since the task of calculating added costs for all products in this SIC Product group by your company may be great, it may be expedient and possible to use a representative sample consisting of one or more typical items or products selected from the group of products being reported to serve as a basis for estimating the cost for the entire SIC product group of the company. However, with the exception of question e in Section 1 or question f in Section 2, the information requested is for the total of all items in the 4-digit SIC product group produced by your company.

INSTRUCTIONS FOR SECTION 1:

a. State the SIC 4-digit product group covered by this questionnaire. It should be the same as that shown to the left of your company name and address in Part A.

b. Check the box that includes the value of sales for all products produced by your company in the stated 4-digit SIC product group.

c. Note that a percentage is requested, the ratio of value of materials to your total value of sales of this 4-digit SIC product group produced by you, multiplied by 100.

d. A percentage is requested, the ratio of total "in-house net added cost" of metrication to your total value of sales of this 4-digit SIC product group produced by you, multiplied by 100. In the determination of total in-house net added cost it should be remembered that (1) any added cost of standard parts and standard materials are to be excluded and (2) savings are to be subtracted from added costs thus resulting in a total in-house net added cost of metrication. In cases in which this net added cost is negative, the percentage reported will be negative and should be prominently so marked.

f. Enter the number of years that you have determined is the optimum period of transition for this SIC product group produced by your company.

g. If the net added cost (added cost minus savings) is negative for any item or area of investigation, the percentage reported will be negative and should be prominently so marked. However, the sum of 1 through 8 should total 100 (or minus 100 if the percentage value in d is negative).

h. Because of the interrelationships, or interlocking, of various industries we would like to determine what the cost impact would be if your company converted this product to metric measurement during a coordinated national program of metrication of 10-year duration based on voluntary participation. Your considered estimate will be appreciated.

INSTRUCTIONS FOR SECTION 2:

a. State the SIC 4-digit product group covered by this questionnaire. It should be the same as that shown to the left of your company name and address in Part A.

b. Check the box that includes the value of sales for all products produced by your company in the stated 4-digit SIC product group.

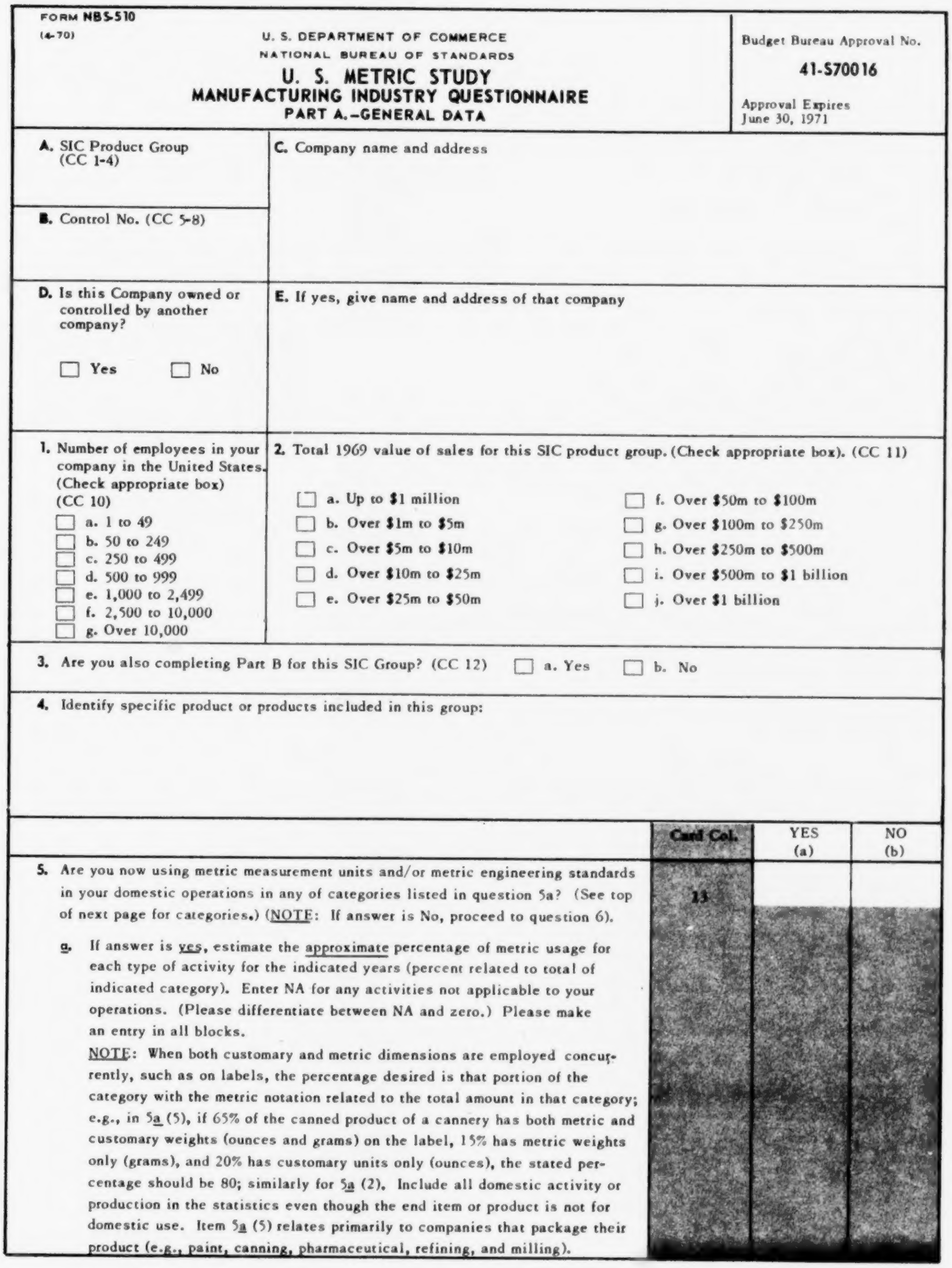
c. Note that a percentage is requested, the ratio of value of materials to your total value of sales of this 4-digit SIC product group produced by you, multiplied by 100.

d. A percentage is requested, the ratio of the total in-house net added cost for development of capability to supply standard parts and/or standard materials to both customary standards and metric standards as metric standards are developed to your total value of sales of this 4-digit SIC product group produced by you, multiplied by 100. In the determination of total in-house net added cost it should be remembered that (1) any added cost of standard parts and standard materials other than the product group reported is to be excluded and (2) savings are to be subtracted from added costs thus resulting in a total in-house net added cost of metrication. In cases in which this net added cost is negative, the percentage reported will be negative and should be prominently so marked.

e. A percentage is requested, the ratio of the annual in-house net added cost for maintaining capability to supply standard parts and/or standard materials to both customary standards and metric standards to your total value of sales of this 4-digit SIC product group produced by you, multiplied by 100.

g. If the net added cost (added cost minus savings) is negative for any item or area of investigation, the percentage reported will be negative and should be prominently so marked. However, the sum of 1 through 8 should total 100 (or minus 100 if the percentage value in d or e is negative).

We may wish to communicate with your company regarding some item in this report. Accordingly, please designate at the end of the questionnaire the person you wish us to contact.



FORM NBS-510
(4-70)

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

U. S. METRIC STUDY
MANUFACTURING INDUSTRY QUESTIONNAIRE
PART A.–GENERAL DATA

Budget Bureau Approval No.
41-S70016
Approval Expires
June 30, 1971

A. SIC Product Group (CC 1-4)

B. Control No. (CC 5-8)

C. Company name and address

D. Is this Company owned or controlled by another company?

☐ Yes ☐ No

E. If yes, give name and address of that company

1. Number of employees in your company in the United States. (Check appropriate box) (CC 10)

- ☐ a. 1 to 49
- ☐ b. 50 to 249
- ☐ c. 250 to 499
- ☐ d. 500 to 999
- ☐ e. 1,000 to 2,499
- ☐ f. 2,500 to 10,000
- ☐ g. Over 10,000

2. Total 1969 value of sales for this SIC product group. (Check appropriate box). (CC 11)

- ☐ a. Up to $1 million
- ☐ b. Over $1m to $5m
- ☐ c. Over $5m to $10m
- ☐ d. Over $10m to $25m
- ☐ e. Over $25m to $50m
- ☐ f. Over $50m to $100m
- ☐ g. Over $100m to $250m
- ☐ h. Over $250m to $500m
- ☐ i. Over $500m to $1 billion
- ☐ j. Over $1 billion

3. Are you also completing Part B for this SIC Group? (CC 12) ☐ a. Yes ☐ b. No

4. Identify specific product or products included in this group:

	Card Col.	YES (a)	NO (b)
5. Are you now using metric measurement units and/or metric engineering standards in your domestic operations in any of categories listed in question 5a? (See top of next page for categories.) (NOTE: If answer is No, proceed to question 6).	13		

a. If answer is yes, estimate the approximate percentage of metric usage for each type of activity for the indicated years (percent related to total of indicated category). Enter NA for any activities not applicable to your operations. (Please differentiate between NA and zero.) Please make an entry in all blocks.

NOTE: When both customary and metric dimensions are employed concurrently, such as on labels, the percentage desired is that portion of the category with the metric notation related to the total amount in that category; e.g., in 5a (5), if 65% of the canned product of a cannery has both metric and customary weights (ounces and grams) on the label, 15% has metric weights only (grams), and 20% has customary units only (ounces), the stated percentage should be 80; similarly for 5a (2). Include all domestic activity or production in the statistics even though the end item or product is not for domestic use. Item 5a (5) relates primarily to companies that package their product (e.g., paint, canning, pharmaceutical, refining, and milling).

5.	ACTIVITY	[illegible]	5 yrs. ago (1965)	Current (1970)	Future (1975)
a.	(1) Design, Engineering, Shop Drawings (% related to total man-hours in this activity)	[illegible]			
	(2) Catalogues (% related to total number of catalogues)	[illegible]			
	(3) Research and Development (% related to total man-hours in this activity)	[illegible]			
	(4) Manufacturing process, including tooling and test equipment (% related to total man-hours in this activity)	[illegible]			
	(5) Labeling (% related to total product packaged)	[illegible]			
	(6) Other (specify)	[illegible]			
b.	If you are presently using metric measurement units in any of your shop drawings:		Card Cols.	YES (a)	NO (b)
	(1) Do you use metric dimensions exclusively?		68		
	(2) Do you use dual dimensions?		69		
	(3) Do you use both metric and customary drawings?		70		
c.	If your use of metric measurement units and/or metric engineering standards have you experienced advantages in the following areas: (Check applicable boxes)	Card Cols.	YES (a)	NO (b)	DON'T KNOW (c)
	(1) Training personnel	10			
	(2) Economy in engineering design and drafting	11			
	(3) Fewer sales items to comprise complete lines (e.g., fewer sizes of bearings or machine screws in standard line, etc.)	12			
	(4) Fewer production items in inventory (e.g., fewer sizes of taps to match fewer sizes of machine screws, etc.)	13			
	(5) Economies in the manufacturing process	14			
	(6) Expanded exports	15			
	(7) Decrease of competitive imports	16			
	(8) Improved competitive position	17			
	(9) Increase of domestic sales	18			
	(10) Simplified specifications, cataloguing and records	19			
	(11) Improved Intra-company liaison and records	20			
	(12) Other advantages (list)	21			
d.	In your use of metric measurement units and/or metric engineering standards, have you experienced disadvantages in the following areas: (Check applicable boxes)		YES (a)	NO (b)	DON'T KNOW (c)
	(1) Training personnel				
	(2) Dual dimensioning or duplication of drawings				
	(3) More sales items to comprise complete lines (e.g., more sizes of bearings or machine screws in standard line, etc.)				
	(4) More production items in inventory (e.g., more sizes of bearings or machine screws etc.)				
	(5) Increased waste in the manufacturing process				
	(6) Difficulty in obtaining metric sized parts and tools				
	(7) Increase of competitive imports				
	(8) Impaired competitive position				
	(9) Decrease of domestic sales				
	(10) Conflict with existing statutes				
	(11) Impaired Intra-company liaison and records				
	(12) Other disadvantages (list)				

5\.

a. In your opinion how do advantages and disadvantages relate to each other? (CC 34)

☐ (1) advantages outweigh disadvantages ☐ (3) No significant difference

☐ (2) disadvantages outweigh advantages ☐ (4) Don't know

(NOTE: If you answered "yes" to 5, proceed to question 7.)

6. Are you currently planning to introduce the use of metric measurement units and/or metric engineering standards in your domestic operations by the end of 1975 regardless of any action that the nation as a whole might take? ☐ Yes ☐ No (CC 35)

a. If yes, indicate the approximate percentage of metric usage for each type of activity by the end of 1975 (% related to total of category). Enter NA for any activities not applicable to your operations. (Please differentiate between NA and zero.) NOTE: When both customary and metric dimensions are employed concurrently, such as on labels, the percentage desired is that portion of the category with the metric notation related to the total amount in that category; e.g., in 6a (5), if 65% of the canned product of a cannery has both metric and customary weights (ounces and grams) on the label, 15% has metric weights only (grams), and 20% has customary units only (ounces), the stated percentage should be 80; similarly for 6a (2). Include all domestic activity or production in the statistics even though the end item or product is not for domestic use. Item 6a (5) relates primarily to companies that package their product (e.g., paint, canning, pharmaceutical, refining, and milling).

ACTIVITY	[redacted]	Percent
(1) Design, Engineering, Shop Drawings (% related to total man-hours in this activity)	[redacted]	%
(2) Catalogues (% related to total number of catalogues)	[redacted]	%
(3) Research and Development (% related to total man-hours in this activity)	[redacted]	%
(4) Manufacturing process including tooling and test equipment (% related to total man-hours in this activity)	[redacted]	%
(5) Labeling (% related to total product packaged)	[redacted]	%
(6) Other (list)	[redacted]	%

(NOTE: If you answered "no" to both 5 and 6, proceed to question 8.)

7. If you are using or plan to use metric measurement units and/or metric engineering standards in your domestic operations, what factors were instrumental in your decision to take this course of action (Check 1 or more):

INSTRUMENTAL FACTORS	[redacted]	YES (a)	NO (b)
(1) Economies resulting from simplification due to the use of metric units	[redacted]		
(2) Expectation of increased export market	[redacted]		
(3) Economy of importation of standard metric components	[redacted]		
(4) Advantages resulting from having one basic system of measurement in your worldwide production	[redacted]		
(5) Mating with standard metric design components	[redacted]		
(6) Other factors (specify)	[redacted]		

8. If you are using any materials or components designed to metric engineering standards in your domestic operations, do these standards cover the items listed below?

NOTE: Bear in mind that even though the product you manufacture may be described in customary units, some materials or components may be based, in whole or in part, on metric engineering standards; e.g., spark plugs, certain types of bearings, fasteners, or sheet metal, especially if they are imported. (Check appropriate box)

ITEMS	[redacted]	YES	NO	DON'T KNOW
(1) Fasteners (nuts, bolts, etc.)	[redacted]			
(2) Electrical connectors and fuses	[redacted]			
(3) Pipe and pipe fittings	[redacted]			
(4) Metric sizes of sheet, barstock, etc.	[redacted]			
(5) Bearings	[redacted]			
(6) Other areas (specify)	[redacted]			
	[redacted]			
	[redacted]			
	[redacted]			

	Card. Col.	YES (a)	NO (b)
9. Are any of your U.S.-made products in this SIC product group exported?	66		

a. If yes, what percent is exported (related to total value of sales)? (CC 67)
☐ Less than 5% ☐ 5% to 25% ☐ More than 25%

b. If your product is exported, does this export necessitate changes or modifications in the following categories?
NOTE: Item b (1) refers to metric notations of weight, size or volume on the label or package; e.g., on candy bars, packaged flour, or canned vegetables. Item b (6) on the other hand refers to the container itself. If you have to package paint in liter can sizes (1.057 U.S. quarts) for export you would check "Yes" for b (6) as well as for b (1). If you export paint in quart sizes and have the notation .946 liter on the can, you would check "No" for b (6), but at the same time you would check "Yes" for b (1).

CATEGORY	Card Col.	YES (a)	NO (b)
(1) Metric measurement units in labeling	68		
(2) Metric measurement units in instructions	69		
(3) Metric measurement units in descriptions	70		
(4) Metric measurement units on your dials, gages, etc.	71		
(5) Design of product to metric modules	72		
(6) Metric size containers	73		
(7) Metric engineering standards	74		
(8) Other modifications (specify)	75		

10. Do you have manufacturing agreements or operations in foreign countries?	76		
a. If yes, does this manufacture involve metric units and/or metric engineering standards?	77		
11. If you manufacture in the United States under an agreement with a foreign company is the product or process described in metric measurement units?	78		
a. If yes, are the metric units translated into customary units in your operations?			

NOTE: In your answers to questions 5 to 11 inclusive you supplied information regarding your current and anticipated use of the metric system and the current and expected impact of this usage. The nature of those questions is such that they elicited information based on the existing environment of no coordinated action on a national scale with regard to metrication and a continuation of the present practice of using the metric system or retaining the customary system when either appears to be economically and technically preferable to the other as a matter of individual company policy.

The following three questions (12, 13, and 14) are to be answered based on the assumption by you, solely for the purpose of answering these three questions, that there will be a coordinated national program of metrication based on voluntary participation in accord with which:

1. The use of metric units and metric engineering standards will be increased only for new or redesigned products or new or redesigned parts of the product. Unless there are distinct advantages in changing, the production of an existing item will remain unchanged until the normal design life cycle of that product is completed and a new metric-designed product replaces it.

2. In-house designed products or components will be designed in metric units on a schedule that is compatible with normal obsolescence of tooling or with economically feasible conversion of tooling from customary to metric units. Existing items of production equipment will be used until their normal life cycles are completed; the only changes or conversion to metric units will be in dials, gages, some feed-rate controls, and indicating devices. Such changes will be made on an economic basis (i.e., when the demand for metric designed parts or products requires a change).

3. Out-of-house production materials and components based on metric engineering standards will become available during the transition period at no substantial increase in cost.

4. The transition period for your product group will be the time in which the transition of the product from customary units and customary engineering standards to metric units and metric engineering standards where appropriate can be accomplished at minimum cost to your company.

5. The metric system will be taught in all U.S. schools during the transition period and the general public will concurrently be gaining familiarity with this system of measurement.

12. What advantages or disadvantages do you foresee from the standpoint of the domestic operations of your company if a coordinated national program of metrication based on voluntary participation is followed in most sectors of the economy.

	Card Col.	YES (a)	NO (b)	DON'T KNOW
a. With respect to advantages:				
(1) Training personnel	10			
(2) Economy in engineering design and drafting	11			
(3) Fewer sales items to comprise complete lines (e.g., fewer sizes of bearings or machine screws in standard line, etc.)	12			
(4) Fewer production items in inventory (e.g., fewer sizes of taps to match fewer sizes of machine screws, etc.)	13			
(5) Economies in the manufacturing process	14			
(6) Expanded exports	15			
(7) Decrease of competitive imports	16			
(8) Improved competitive position	17			
(9) Increase of domestic sales	18			
(10) Simplified specifications, cataloguing and records	19			
(11) Improved Intra-company liaison and records	20			
(12) Other advantages (list)	21			
b. With respect to disadvantages:				
(1) Training personnel	22			
(2) Dual dimensioning or duplication of drawings	23			
(3) More sales items to comprise complete lines (e.g., more sizes of bearings or machine screws in standard line, etc.)	24			
(4) More production items in inventory (e.g., more sizes of bearings or machine screws, etc.)	25			
(5) Increased waste in the manufacturing process	26			
(6) Difficulty in obtaining metric sized parts and tools	27			
(7) Increase of competitive imports	28			
(8) Impaired competitive position	29			
(9) Decrease of domestic sales	30			
(10) Conflict with existing statutes	31			
(11) Impaired Intra-company liaison and records	32			
(12) Other disadvantages (list)	33			

c. In your opinion how do advantages and disadvantages relate to each other? (CC 34)

☐ (1) advantages outweigh disadvantages ☐ (3) No significant difference
☐ (2) disadvantages outweigh advantages ☐ (4) Don't know

NOTE: Answering question 13 is optional for suppliers of standard materials and standard parts.

13. What is your estimate of the number of years necessary to achieve your maximum increased metric usage with minimum cost and disruptions to your company under a coordinated national program of metrication based on voluntary participation covering essentially all sectors of the economy? (CC 35-36) ______________________ years

14. If your company were to substantially convert to metric measurement units and/or metric engineering standards under a coordinated national program of metrication based on voluntary participation covering essentially all sectors of the economy, do you anticipate that this would have any effect on your sales because of importation of metric products (assume year 1980 but base your answer on 1969 dollars)? (Check one) (CC 37)

☐ (a) No effect ☐ (b) Loss of sales ☐ (c) Don't know

a. If "loss of sales" is checked, what, in your opinion, would this loss be in 1980 as percent of your current domestic sales based on 1969 dollars? (Check one) (CC 38)

☐ (a) Up to 5% ☐ (c) 10–20% ☐ (e) Don't know
☐ (b) 5–10% ☐ (d) Over 20%

15. If your product is not now exported would you expect to export it if your company substantially converts to metric measurement units and/or metric engineering standards (assume year 1980)? (CC39) ☐ (a) Yes ☐ (b) No

16. If your product is now exported, do you anticipate that if your company were to substantially convert to metric measurement units and/or metric engineering standards this would have any effect on your export sales (assume year 1980 but base your answer on 1969 dollars)? (Check one) (CC 40)

☐ (a) No effect
☐ (b) Increase in export sales
☐ (c) Decrease in export sales
☐ (d) Don't know

a. If "Increase in export sales" is checked, what, in your opinion, would this increase be in 1980 as % of your current export sales based on 1969 dollars? (Check one) (CC 41)

☐ (a) Up to 10%
☐ (b) 10–25%
☐ (c) 25–50%
☐ (d) Over 50%
☐ (e) Don't know

b. If "Decrease in export sales" is checked, what, in your opinion, would this decrease be in 1980 as % of your current export sales based on 1969 dollars? (Check one) (CC 42)

☐ (a) Up to 10%
☐ (b) 10–25%
☐ (c) 25–50%
☐ (d) Over 50%
☐ (e) Don't know

17. Please check block that most closely indicates the current attitude of your company toward increased metric usage regarding this SIC product group: (CC 43)

☐ (a) Strongly for
☐ (b) Mildly for
☐ (c) Neutral
☐ (d) Mildly against
☐ (e) Strongly against

18. Do you believe that increased metric usage is in the best interests of the United States? (CC 44)

☐ (a) Yes
☐ (b) No

19. If it is found that increased metric usage is in the best interests of the United States, which of the following courses of action, in your opinion, is preferable? (CC 45)

☐ (a) No national program of metrication
☐ (b) A coordinated national program based on voluntary participation
☐ (c) A mandatory program based on legislation

20. If it is found that increased metric usage is in the best interests of the United States, in your opinion, should any engineering standards based on the customary system of measurement units and applicable to this SIC No. be retained and promoted for international use? (CC 46)

☐ (a) Yes
☐ (b) No
☐ (c) Don't know

a. If yes, please list the one or two most important standards applicable to this SIC No.

____

____

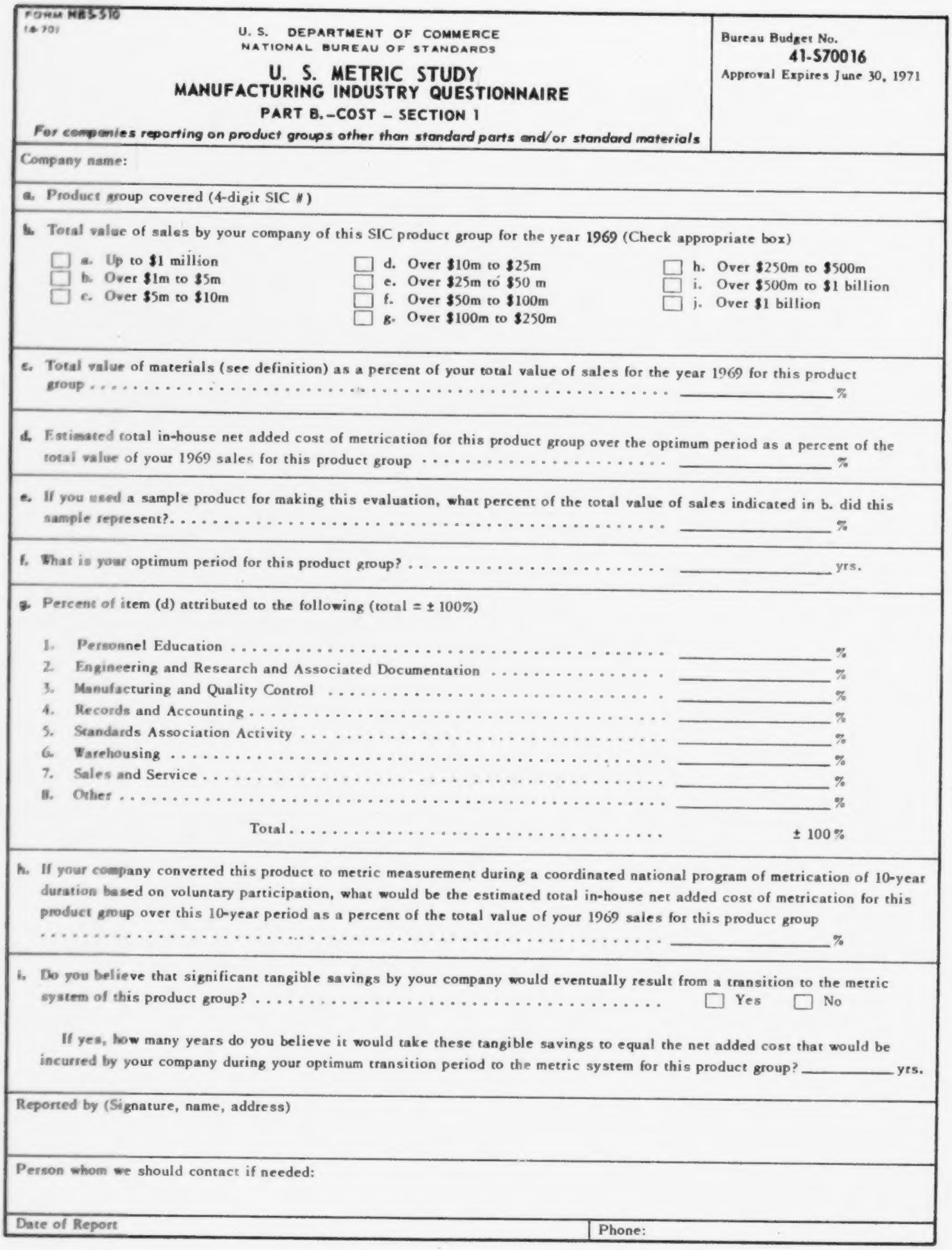
21. General comment, if any, on the subject of metric usage in your company. Comments should be made on a separate attachment.

(It is not necessary to answer this question, but any opinion on the general subject of metrication will be appreciated. For example, are there any problems peculiar to your company not covered in this questionnaire? Other questions or comments regarding metrication may occur to you.)

Reported by (Signature, name, address)

Person whom we should contact if needed:

Date reported	Phone:



FORM NBS-510
(4-70)

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

U. S. METRIC STUDY
MANUFACTURING INDUSTRY QUESTIONNAIRE
PART B.–COST – SECTION 1

For companies reporting on product groups other than standard parts and/or standard materials

Bureau Budget No.
41-S70016
Approval Expires June 30, 1971

Company name:

a. Product group covered (4-digit SIC #)

b. Total value of sales by your company of this SIC product group for the year 1969 (Check appropriate box)

☐ a. Up to $1 million
☐ b. Over $1m to $5m
☐ c. Over $5m to $10m
☐ d. Over $10m to $25m
☐ e. Over $25m to $50 m
☐ f. Over $50m to $100m
☐ g. Over $100m to $250m
☐ h. Over $250m to $500m
☐ i. Over $500m to $1 billion
☐ j. Over $1 billion

c. Total value of materials (see definition) as a percent of your total value of sales for the year 1969 for this product group . . . . ________ %

d. Estimated total in-house net added cost of metrication for this product group over the optimum period as a percent of the total value of your 1969 sales for this product group . . . . ________ %

e. If you used a sample product for making this evaluation, what percent of the total value of sales indicated in b. did this sample represent? . . . . ________ %

f. What is your optimum period for this product group? . . . . ________ yrs.

g. Percent of item (d) attributed to the following (total = ± 100%)

1. Personnel Education . . . . ________ %
2. Engineering and Research and Associated Documentation . . . . ________ %
3. Manufacturing and Quality Control . . . . ________ %
4. Records and Accounting . . . . ________ %
5. Standards Association Activity . . . . ________ %
6. Warehousing . . . . ________ %
7. Sales and Service . . . . ________ %
8. Other . . . . ________ %

Total . . . . ± 100 %

h. If your company converted this product to metric measurement during a coordinated national program of metrication of 10-year duration based on voluntary participation, what would be the estimated total in-house net added cost of metrication for this product group over this 10-year period as a percent of the total value of your 1969 sales for this product group . . . . ________ %

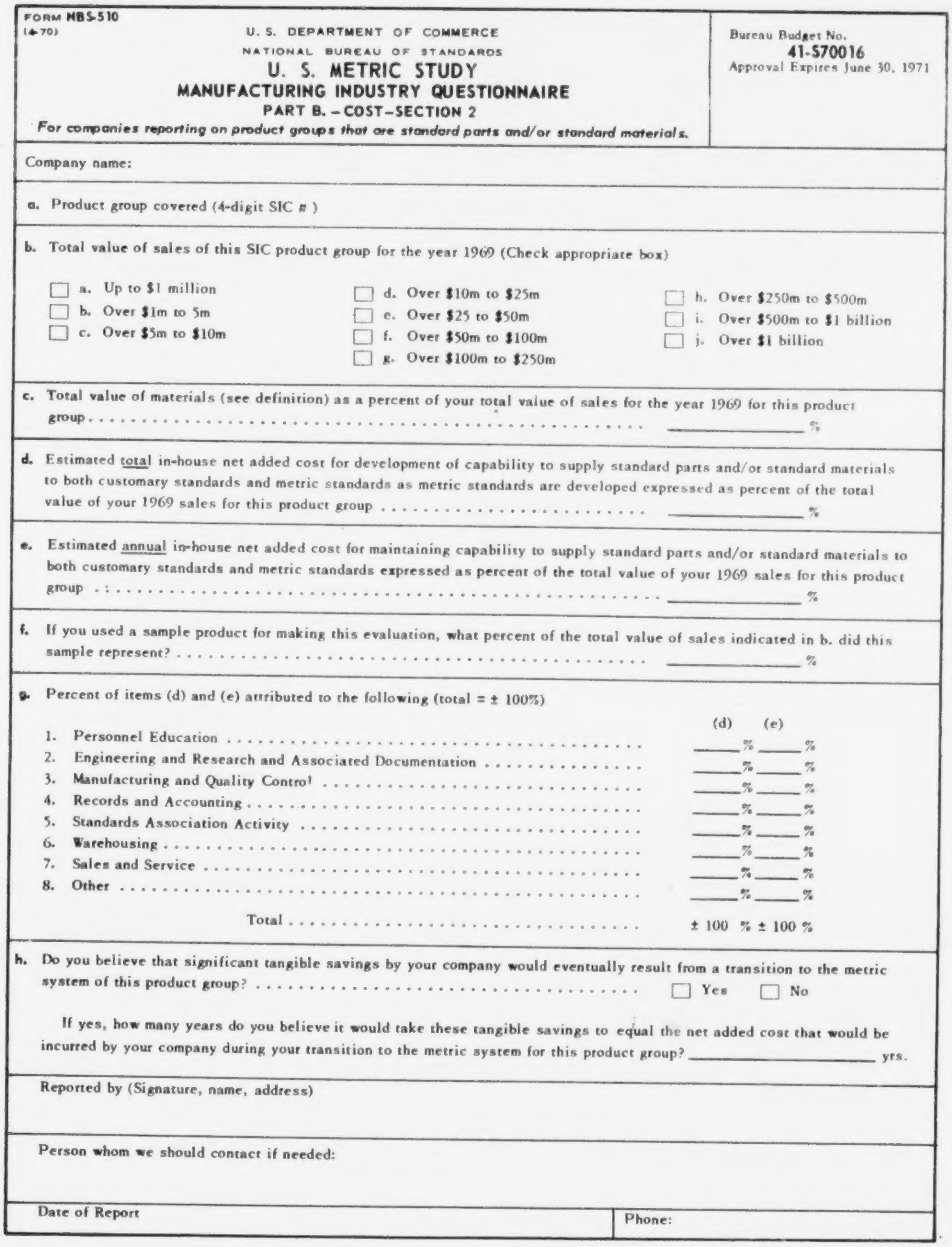
i. Do you believe that significant tangible savings by your company would eventually result from a transition to the metric system of this product group? . . . . ☐ Yes ☐ No

If yes, how many years do you believe it would take these tangible savings to equal the net added cost that would be incurred by your company during your optimum transition period to the metric system for this product group? ________ yrs.

Reported by (Signature, name, address)

Person whom we should contact if needed:

Date of Report	Phone:



FORM NBS-510
(4-70)

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

U. S. METRIC STUDY
MANUFACTURING INDUSTRY QUESTIONNAIRE
PART B. – COST–SECTION 2

For companies reporting on product groups that are standard parts and/or standard materials.

Bureau Budget No.
41-S70016
Approval Expires June 30, 1971

Company name:

a. Product group covered (4-digit SIC #)

b. Total value of sales of this SIC product group for the year 1969 (Check appropriate box)

☐ a. Up to $1 million
☐ b. Over $1m to 5m
☐ c. Over $5m to $10m
☐ d. Over $10m to $25m
☐ e. Over $25 to $50m
☐ f. Over $50m to $100m
☐ g. Over $100m to $250m
☐ h. Over $250m to $500m
☐ i. Over $500m to $1 billion
☐ j. Over $1 billion

c. Total value of materials (see definition) as a percent of your total value of sales for the year 1969 for this product group . . . . ________ %

d. Estimated total in-house net added cost for development of capability to supply standard parts and/or standard materials to both customary standards and metric standards as metric standards are developed expressed as percent of the total value of your 1969 sales for this product group . . . . ________ %

e. Estimated annual in-house net added cost for maintaining capability to supply standard parts and/or standard materials to both customary standards and metric standards expressed as percent of the total value of your 1969 sales for this product group . : . . . . ________ %

f. If you used a sample product for making this evaluation, what percent of the total value of sales indicated in b. did this sample represent? . . . . ________ %

g. Percent of items (d) and (e) attributed to the following (total = ± 100%)

		(d)	(e)
1.	Personnel Education	____%	____%
2.	Engineering and Research and Associated Documentation	____%	____%
3.	Manufacturing and Quality Control	____%	____%
4.	Records and Accounting	____%	____%
5.	Standards Association Activity	____%	____%
6.	Warehousing	____%	____%
7.	Sales and Service	____%	____%
8.	Other	____%	____%
	Total	± 100 %	± 100 %

h. Do you believe that significant tangible savings by your company would eventually result from a transition to the metric system of this product group? . . . . ☐ Yes ☐ No

If yes, how many years do you believe it would take these tangible savings to equal the net added cost that would be incurred by your company during your transition to the metric system for this product group? ____________ yrs.

Reported by (Signature, name, address)

Person whom we should contact if needed:

Date of Report

Phone:

ORIGINAL AND REVISED SIC CATEGORIES

This appendix contains (1) the original SIC categories (i.e., all SIC product codes selected for category I, II, or III), and (2) the revised SIC categories (i.e., all SIC product codes selected for category A, B, or C).

SIC categories A, B, and C are the categories on which the findings, analyses, and conclusions are based, and the categories shown in the detailed tables contained in appendix E.

A background discussion of the SIC categories is given in chapter I, section D.1.

ORIGINAL SIC CATEGORIES

CATEGORY I

	1911	Guns, Howitzers, Mortars, and Related Equipment
	1925	Guided Missiles and Space Vehicles, Completely Assembled
	1931	Tanks and Tank Components
	1941	Sighting and Fire Control Equipment
	1951	Small Arms
351		Engines and Turbines
	3511	Steam Engines; Steam, Gas, and Hydraulic Turbines; and Steam, Gas, and Hydraulic Turbine Generator Set Units
	3519	Internal Combustion Engines, Not Elsewhere Classified
	3522	Farm Machinery and Equipment
353		Construction, Mining, and Materials Handling Machinery and Equipment
	3531	Construction Machinery and Equipment
	3532	Mining Machinery and Equipment, Except Oil Field Machinery and Equipment
	3533	Oil Field Machinery and Equipment
	3534	Elevators and Moving Stairways
	3535	Conveyors and Conveying Equipment
	3536	Hoists, Industrial Cranes, and Monorail Systems
	3537	Industrial Trucks, Tractors, Trailers, and Stackers
	3541	Machine Tools, Metal Cutting Types
	3542	Machine Tools, Metal Forming Types
	3544	Special Dies and Tools, Die Sets, Jigs and Fixtures
	3548	Metalworking Machinery, Except Machine Tools; and Power Driven Hand Tools
355		Special Industry Machinery, Except Metalworking Machinery
	3551	Food Products Machinery
	3552	Textile Machinery
	3553	Woodworking Machinery
	3554	Paper Industries Machinery

3555	Printing Trades Machinery and Equipment
3559	Special Industry Machinery, Not Elsewhere Classified
3561	Pumps, Air and Gas Compressors, and Pumping Equipment
357	Office, Computing, and Accounting Machines
3572	Typewriters
3573	Electronic Computing Equipment
3574	Calculating and Accounting Machines, Except Electronic Computing Equipment
3576	Scales and Balances, Except Laboratory
3579	Office Machines, Not Elsewhere Classified
358	Service Industry Machines
3581	Automatic Merchandising Machines
3582	Commercial Laundry, Dry Cleaning, and Pressing Machines
3585	Air Conditioning Equipment and Commercial and Industrial Refrigeration Machinery and Equipment
3586	Measuring and Dispensing Pumps
3589	Service Industry Machines, Not Elsewhere Classified
362	Electrical Industrial Apparatus
3621	Motors and Generators
3622	Industrial Controls
3623	Welding Apparatus
3624	Carbon and Graphite Products
3629	Electrical Industrial Apparatus, Not Elsewhere Classified
363	Household Appliances
3631	Household Cooking Equipment
3632	Household Refrigerators and Home and Farm Freezers
3633	Household Laundry Equipment
3634	Electric Housewares and Fans
3635	Household Vacuum Cleaners
3636	Sewing Machines
3639	Household Appliances, Not Elsewhere Classified
366	Communication Equipment
3661	Telephone and Telegraph Apparatus
3662	Radio and Television Transmitting, Signaling, and Detection Equipment and Apparatus
371	Motor Vehicles and Motor Vehicle Equipment
3711	Motor Vehicles
3712	Passenger Car Bodies
3713	Truck and Bus Bodies
3714	Motor Vehicle Parts and Accessories
3715	Truck Trailers (Full)
372	Aircraft and Parts
3721	Aircraft
3722	Aircraft Engines and Engine Parts
3723	Aircraft Propellers and Propeller Parts
3729	Aircraft Parts and Auxiliary Equipment, Not Elsewhere Classified

3731	Ship Building and Repairing
374	Railroad Equipment
3741	Locomotives and Parts
3742	Railroad and Street Cars
3751	Motorcycles, Bicycles and Parts

CATEGORY II

1999	Ordnance and Accessories, Not Elsewhere Classified
202	Dairy Products
2021	Creamery Butter
2022	Cheese, Natural and Processed
2023	Condensed and Evaporated Milk
2024	Ice Cream and Frozen Desserts
2026	Fluid Milk
203	Canned and Preserved Fruits, Vegetables, and Sea Foods
2031	Canned and Cured Fish and Sea Foods
2032	Canned Specialties
2033	Canned Fruits, Vegetables; Preserves, Jams, and Jellies
2034	Dried and Dehydrated Fruits and Vegetables
2035	Pickled Fruits and Vegetables; Vegetable Sauces and Seasonings; Salad Dressings
2036	Fresh or Frozen Packaged Fish and Sea Foods
2037	Frozen Fruits, Fruit Juices, Vegetables, and Specialties
242	Sawmills and Planing Mills
2421	Sawmills and Planing Mills, General
2426	Hardwood Dimension and Flooring Mills
2429	Special Product Saw Mills, Not Elsewhere Classified
243	Millwork, Veneer, Plywood, and Prefabricated Structural Wood Products
2431	Millwork
2432	Veneer and Plywood
2433	Prefabricated Wooden Buildings and Structural Members
2621	Paper Mills, Except Building Paper Mills
2631	Paperboard Mills
2761	Manifold Business Forms
281	Industrial Inorganic and Organic Chemicals
2812	Alkalies and Chlorine
2813	Industrial Gases
2815	Cyclic Intermediates, Dyes, Organic Pigments (Lakes and Toners), and Cyclic (Coal Tar) Crudes
2816	Inorganic Pigments
2818	Industrial Organic Chemicals, Not Elsewhere Classified
2819	Industrial Inorganic Chemicals, Not Elsewhere Classified
282	Plastic Materials and Synthetic Resins, Synthetic Rubber, Synthetic and Other Man-Made Fibers, Except Glass
2821	Plastic Materials, Synthetic Resins, and Nonvulcanizable Elastomers

2822	Synthetic Rubber (Vulcanizable Elastomers)
2823	Cellulosic Man-Made Fibers
2824	Synthetic Organic Fibers, Except Cellulosic
283	Drugs
2831	Biological Products
2833	Medicinal Chemicals and Botanical Products
2834	Pharmaceutical Preparations
2911	Petroleum Refining
295	Paving and Roofing Materials
2951	Paving Mixtures and Blocks
2952	Asphalt Felts and Coatings
331	Blast Furnaces, Steel Works, and Rolling and Finishing Mills
3312	Blast Furnaces (Including Coke Ovens), Steel Works, and Rolling Mills
3313	Electrometallurgical Products
3315	Steel Wire Drawings and Steel Nails and Spikes
3316	Cold Rolled Steel Sheet, Strip, and Bars
3317	Steel Pipe and Tubes
333	Primary Smelting and Refining of Nonferrous Metals
3331	Primary Smelting and Refining of Copper
3332	Primary Smelting and Refining of Lead
3333	Primary Smelting and Refining of Zinc
3334	Primary Production of Aluminum
3339	Primary Smelting and Refining of Nonferrous Metals, Not Elsewhere Classified
335	Rolling, Drawing, and Extruding of Nonferrous Metals
3351	Rolling, Drawing, and Extruding of Copper
3352	Rolling, Drawing, and Extruding of Aluminum
3356	Rolling, Drawing, and Extruding of Nonferrous Metals, Except Copper and Aluminum
3357	Drawing and Insulating of Nonferrous Wire
339	Miscellaneous Primary Metal Products
3391	Iron and Steel Forgings
3392	Nonferrous Forgings
3399	Primary Metal Products, Not Elsewhere Classified
3411	Metal Cans
3433	Heating Equipment, Except Electric
3441	Fabricated Structural Steel
3443	Fabricated Plate Work (Boiler Shops)
345	Screw Machine Products, and Bolts, Nuts, Screws, Rivets and Washers
3451	Screw Machine Products
3452	Bolts, Nuts, Screws, Rivets and Washers
3461	Metal Stampings
3494	Valves and Pipe Fittings, Except Plumbers' Brass Goods
3498	Fabricated Pipe and Fabricated Pipe Fittings
3545	Machine Tool Accessories and Measuring Devices
3562	Ball and Roller Bearings

3564	Blowers and Exhaust and Ventilation Fans
3565	Industrial Patterns
3566	Mechanical Power Transmission Equipment, Except Ball and Roller Bearings
3567	Industrial Process Furnaces and Ovens
3569	General Industrial Machinery and Equipment, Not Elsewhere Classified
3599	Miscellaneous Machinery, Except Electrical
361	Electric Transmission and Distribution Equipment
3611	Electric Measuring Instruments and Test Equipment
3612	Power, Distribution, and Specialty Transformers
3613	Switchgear and Switchboard Apparatus
364	Electric Lighting and Wiring Equipment
3641	Electric Lamps
3642	Lighting Fixtures
3643	Current-Carrying Wiring Devices
3644	Noncurrent-Carrying Wiring Devices
3651	Radio and Television Receiving Sets, Except Communication Types
367	Electronic Components and Accessories
3671	Radio and Television Receiving Type Electron Tubes, Except Cathode Ray
3672	Cathode Ray Picture Tubes
3673	Transmitting, Industrial, and Special Purpose Electron Tubes
3674	Semiconductors and Related Devices
3679	Electronic Components and Accessories, Not Elsewhere Classified
3732	Boat Building and Repairing
379	Miscellaneous Transportation Equipment
3791	Trailer Coaches
3799	Transportation Equipment, Not Elsewhere Classified
3811	Engineering, Laboratory, and Scientific and Research Instruments and Associated Equipment
382	Instruments for Measuring, Controlling and Indicating Physical Characteristics
3821	Mechanical Measuring and Controlling Instruments, Except Automatic Temperature Controls
3822	Automatic Temperature Controls
3861	Photographic Equipment and Supplies

CATEGORY III

ALL OTHER ITEMS

REVISED SIC CATEGORIES

CATEGORY A

1911	Guns, Howitzers, Mortars, and Related Equipment
1925	Guided Missiles and Space Vehicles, Completely Assembled
1931	Tanks and Tank Components
1941	Sighting and Fire Control Equipment
1951	Small Arms
1999	Ordnance and Accessories, Not Elsewhere Classified
3511	Steam Engines; Steam, Gas, and Hydraulic Turbines; and Steam, Gas, and Hydraulic Turbine Generator Set Units
3519	Internal Combustion Engines, Not Elsewhere Classified
3522	Farm Machinery and Equipment
353	Construction, Mining, and Materials Handling Machinery and Equipment
3531	Construction Machinery and Equipment
3532	Mining Machinery and Equipment, Except Oil Field Machinery and Equipment
3533	Oil Field Machinery and Equipment
3534	Elevators and Moving Stairways
3535	Conveyors and Conveying Equipment
3536	Hoists, Industrial Cranes, and Monorail Systems
3537	Industrial Trucks, Tractors, Trailers, and Stackers
3541	Machine Tools, Metal Cutting Types
3542	Machine Tools, Metal Forming Types
3548	Metalworking Machinery, Except Machine Tools; and Power Driven Hand Tools
355	Special Industry Machinery, Except Metalworking Machinery
3551	Food Products Machinery
3552	Textile Machinery
3553	Woodworking Machinery
3554	Paper Industries Machinery
3555	Printing Trades Machinery and Equipment
3559	Special Industry Machinery, Not Elsewhere Classified
3561	Pumps, Air and Gas Compressors, and Pumping Equipment
3567	Industrial Process Furnaces and Ovens
357	Office, Computing, and Accounting Machines
3572	Typewriters
3573	Electronic Computing Equipment
3574	Calculating and Accounting Machines, Except Electronic Computing Equipment
3576	Scales and Balances, Except Laboratory
3579	Office Machines, Not Elsewhere Classified
358	Service Industry Machines
3581	Automatic Merchandising Machines

3582	Commercial Laundry, Dry Cleaning, and Pressing Machines
3585	Air Conditioning Equipment and Commercial and Industrial Refrigeration Machinery and Equipment
3586	Measuring and Dispensing Pumps
3589	Service Industry Machines, Not Elsewhere Classified
3621	Motors and Generators
3623	Welding Apparatus
363	Household Appliances
3631	Household Cooking Equipment
3632	Household Refrigerators and Home and Farm Freezers
3633	Household Laundry Equipment
3634	Electric Housewares and Fans
3635	Household Vacuum Cleaners
3636	Sewing Machines
3639	Household Appliances, Not Elsewhere Classified
3651	Radio and Television Receiving Sets, Except Communication Types
366	Communication Equipment
3661	Telephone and Telegraph Apparatus
3662	Radio and Television Transmitting, Signaling, and Detection Equipment and Apparatus
3693	Radiographic X-ray, Fluoroscopic X-ray, Therapeutic X-ray, and Other X-ray Apparatus and Tubes; Electromedical and Electrotherapeutic Apparatus
371	Motor Vehicles and Motor Vehicle Equipment
3711	Motor Vehicles
3712	Passenger Car Bodies
3713	Truck and Bus Bodies
3714	Motor Vehicle Parts and Accessories
3715	Truck Trailers (Full)
372	Aircraft and Parts
3721	Aircraft
3722	Aircraft Engines and Engine Parts
3723	Aircraft Propellers and Propeller Parts
3729	Aircraft Parts and Auxiliary Equipment, Not Elsewhere Classified
373	Ship and Boat Building and Repairing
3731	Ship Building and Repairing
3732	Boat Building and Repairing
374	Railroad Equipment
3741	Locomotive and Parts
3742	Railroad and Street Cars
3751	Motorcycles, Bicycles, and Parts
379	Miscellaneous Transportation Equipment
3791	Trailer Coaches
3799	Transportation Equipment, Not Elsewhere Classified

CATEGORY B

2211	Broad Woven Fabric Mills, Cotton
2221	Broad Woven Fabric Mills, Man-Made Fiber and Silk
2231	Broad Woven Fabric Mills, Wool: Including Dyeing and Finishing
2241	Narrow Fabrics and Other Smallwares Mills: Cotton, Wool, Silk, and Man-Made Fiber
225	Knitting Mills
2251	Women's Full Length and Knee Length Hosiery, Seamless and Full-Fashioned
2252	Hosiery, Except Women's Full Length and Knee Length Hosiery
2253	Knit Outerwear Mills
2254	Knit Underwear Mills
2256	Knit Fabric Mills
2259	Knitting Mills, Not Elsewhere Classified
227	Floor Covering Mills
2271	Woven Carpets and Rugs
2272	Tufted Carpets and Rugs
2279	Carpets and Rugs, Not Elsewhere Classified
242	Sawmills and Planing Mills
2421	Sawmills and Planing Mills, General
2426	Hardwood Dimension and Flooring Mills
2429	Special Product Saw Mills, Not Elsewhere Classified
243	Millwork, Veneer, Plywood, and Prefabricated Structural Wood Products
2431	Millwork
2432	Veneer and Plywood
2433	Prefabricated Wooden Buildings and Structural Members
244	Wooden Containers
2441	Nailed and Lock Corner Wooden Boxes and Shook
2442	Wirebound Boxes and Crates
2443	Veneer and Plywood Containers, Except Boxes and Crates
2445	Cooperage
249	Miscellaneous Wood Products
2491	Wood Preserving
2499	Wood Products, Not Elsewhere Classified
2621	Paper Mills, Except Building Paper Mills
2631	Paperboard Mills
265	Paperboard Containers and Boxes
2651	Folding Paperboard Boxes
2652	Set-up Paperboard Boxes
2653	Corrugated and Solid Fiber Boxes
2654	Sanitary Food Containers
2655	Fiber Cans, Tubes, Drums, and Similar Products
2661	Building Paper and Building Board Mills
2761	Manifold Business Forms

	3011	Tires and Inner Tubes
	3211	Flat Glass
	3221	Glass Containers
325		Structural Clay Products
	3251	Brick and Structural Clay Tile
	3253	Ceramic Wall and Floor Tile
	3255	Clay Refractories
	3259	Structural Clay Products, Not Elsewhere Classified
	3271	Concrete Block and Brick
	3272	Concrete Products, Except Block and Brick
331		Blast Furnaces, Steel Works, and Rolling and Finishing Mills
	3312	Blast Furnaces (Including Coke Ovens), Steel Works, and Rolling Mills
	3313	Electrometallurgical Products
	3315	Steel Wire Drawing and Steel Nails and Spikes
	3316	Cold Rolled Steel Sheet, Strip, and Bars
	3317	Steel Pipe and Tubes
332		Iron and Steel Foundries
	3321	Gray Iron Foundries
	3322	Malleable Iron Foundries
	3323	Steel Foundries
335		Rolling, Drawing, and Extruding of Nonferrous Metals
	3351	Rolling, Drawing, and Extruding of Copper
	3352	Rolling, Drawing, and Extruding of Aluminum
	3356	Rolling, Drawing, and Extruding of Nonferrous Metals, Except Cooper and Aluminum
	3357	Drawing and Insulating of Nonferrous Wire
336		Nonferrous Foundries
	3361	Aluminum Castings
	3362	Brass, Bronze, Copper, Copper Base Alloy Castings
	3369	Nonferrous Castings, Not Elsewhere Classified
339		Miscellaneous Primary Metal Products
	3391	Iron and Steel Forgings
	3392	Nonferrous Forgings
	3399	Primary Metal Products, Not Elsewhere Classified
	3411	Metal Cans
	3433	Heating Equipment, Except Electric
344		Fabricated Structural Metal Products
	3441	Fabricated Structural Steel
	3442	Metal Doors, Sash, Frames, Molding, and Trim
	3443	Fabricated Plate Work (Boiler Shops)
	3444	Sheet Metal Work
	3446	Architectural and Ornamental Metal Work
	3449	Miscellaneous Metal Work
345		Screw Machine Products, and Bolts, Nuts, Screws, Rivets and Washers
	3451	Screw Machine Products

3452	Bolts, Nuts, Screws, Rivets and Washers
3461	Metal Stampings
3491	Metal Shipping Barrels, Drums, Kegs, and Pails
3494	Valves and Pipe Fittings, Except Plumbers' Brass Goods
3498	Fabricated Pipe and Fabricated Pipe Fittings
3544	Special Dies and Tools, Die Sets, Jigs and Fixtures
3545	Machine Tool Accessories and Measuring Devices
3562	Ball and Roller Bearings
3564	Blowers and Exhaust and Ventilation Fans
3565	Industrial Patterns
3566	Mechanical Power Transmission Equipment, Except Ball and Roller Bearings
3569	General Industrial Machinery and Equipment, Not Elsewhere Classified
3599	Miscellaneous Machinery, Except Electrical
361	Electric Transmission and Distribution Equipment
3611	Electric Measuring Instruments and Test Equipment
3612	Power, Distribution, and Specialty Transformers
3613	Switchgear and Switchboard Apparatus
3622	Industrial Controls
3624	Carbon and Graphite Products
3629	Electrical Industrial Apparatus, Not Elsewhere Classified
364	Electric Lighting and Wiring Equipment
3641	Electric Lamps
3642	Lighting Fixtures
3643	Current-Carrying Wiring Devices
3644	Noncurrent-Carrying Wiring Devices
367	Electronic Components and Accessories
3671	Radio and Television Receiving Type Electron Tubes, Except Cathode Ray
3672	Cathode Ray Picture Tubes
3673	Transmitting, Industrial, and Special Purpose Electron Tubes
3674	Semiconductors and Related Devices
3679	Electronic Components and Accessories, Not Elsewhere Classified
3694	Electrical Equipment for Internal Combustion Engines
3811	Engineering, Laboratory, and Scientific and Research Instruments and Associated Equipment
3821	Mechanical Measuring and Controlling Instruments, Except Automatic Temperature Controls
3822	Automatic Temperature Controls
3831	Optical Instruments and Lenses
3861	Photographic Equipment and Supplies
3871	Watches, Clocks, Clockwork Operated Devices, and Parts Except Watchcases
3996	Linoleum, Asphalted-Felt-Base, and Other Hard Surface Floor Coverings, Not Elsewhere Classified

CATEGORY C

ALL OTHER ITEMS

Appendix D

SAMPLES OF COMMENTS IN RESPONSE TO QUESTION 21, PART A

This appendix contains samples of open-ended comments made in response to question 21, part A. Firms providing these additional comments were classified for analysis as either small (1-499 employees)[1] or large (500 or more employees)[1] and as present metric users or present nonusers. The resulting four classification groups are:

1. Small present metric user companies
2. Large present metric user companies
3. Small present metric nonuser companies
4. Large present metric nonuser companies

A random sample of one-fourth of the companies making comments was drawn from each of the four classification groups and the comments made by these companies appear by these groups on the following pages of the appendix.

1. SMALL PRESENT METRIC USER COMPANIES

The metric system (MKS) is used by the design engineering department for all theoretical work. This is a way of life in all engineering departments; it certainly is a way of life in engineering schools. The product, however, is always released to the manufacturing division (drawings, specifications, etc.) with a format that reflects the customary system of measurement units.

Some small degree of metrication is found on exported products in the area of instruction and/or descriptive (catalog) material where the physical dimensions and weight of the product are expressed in metric units.

* * *

The experience we have had so far in the use of the metric system has been very favorable. We have five Envelope Folding Machines that are manufactured in West Germany and they are all tooled to the metric system. It seems to me that it is simpler and requires less sizes of screws, tools, etc.

I hope that this answers some of your questions because I realize that this is a pretty gigantic job to get done.

* * *

In reviewing the problem with our personnel, I find that our physicists, chemists, and other scientists strongly favor use of the metric system, while engineering and shop personnel are rather violently against it because of the practical problems involved in the changeover. Nevertheless, it is the general feeling that the change to the metric system is almost inevitable at some time in the not-too-distant future.

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[1] Note: Classification by size (small or large) in this section differs from size classifications in other sections of this report.

* * *

Inventory—we have large stocks of slow-moving raw and finished goods which would be scrap if the change-over period were not of *long* duration.

Tooling—present tooling based upon the present system of measurement could *not* be converted over in a great many cases or only through expensive rework. Replacement parts would be troublesome for years and years.

Design—the bulk of the product line is sized according to English system pipe size. *Years and years* of design records would require a tremendous number of man-hours to rework and redesign.

Production Records—All routining and setup information involving years of records would have to be changed.

Product Longevity—Due to the fact that the product lines are expected to last forty or more years, we would be expected by our customers to supply replacement parts for at least that period, necessitating the maintenance of two complete product lines, one English system and one metric system, at no relative increase in sales to offset increased costs. This is the heart of the matter.

* * *

2. LARGE PRESENT METRIC USER COMPANIES

We presently produce parts for customers whose drawings and specifications are metric. Our drafting section converts all metric to conventional decimals for shop drawings and procedures. The only areas of metric usage is in our chemical laboratory and some very limited engineering specifications.

With the small percentage of metric we use it is impossible to give a good estimate of advantages and disadvantages. If a conversion to metric were made our shop would be starting from essentially a "no-use" base.

In that ours is largely a machining operation to customers specification (no product of our own), a conversion to metric would involve considerable problems and expense in the following areas:

1. All machine dials, lead screws and gearing would have to be converted.
2. All measuring equipment would need to be replaced.
3. Inspection equipment, fixtures and gages would have to be replaced and/or re-calibrated.
4. Furnaces and heat treating equipment would have to be recalibrated.
5. A long training period would be required for machine operators and related support departments, during which time production quantities will drop while reject rates would increase.

The biggest problem in the changeover to the metric system of weights and measures would be that of properly educating personnel. Most of our employees are not well educated and would encounter much difficulty with a new and different system.

The expense of changing would not be excessive if the change were allowed to take place over a period of time covering the normal life of tooling. However, certain mating parts and gauging would have to be altered in conjunction with the change to the metric system.

* * *

Our Company at present, and in the foreseeable future, operates almost entirely within the customary system of measurements. The few exceptions, which account for the small percentages indicated in Item 5a., may be described as follows:

(a) Optics and lens specifications are converted "back and forth" from metric to inch but most generally are specified in metric units. Our optical bench is, of course, metric.
(b) Scientific and laboratory instruments used by us, such as a balance, are generally of the metric type.
(c) Loadings on hardness testers are metric (Kilograms).
(d) Inertias are sometimes specified in metric units (gr. cm^2.).
(e) Temperatures are presently specified in either degrees Centigrade or degrees Fahrenheit. Personnel have developed a "feel" for handling Centigrade temperature units and have become thoroughly familiar with this metric unit.

A considerable number of products designed and built by our Company contain precision gearing. Practically all of our gear design and manufacture is according to the involute system and the parameters are defined by the customary system of measurement.

I am of the opinion that even on a coordinated national program of metrication based on voluntary participation, the assumed year of 1980 (10 years from now) is much too short a time base. I suggest that a period of twenty or even thirty years would be more realistic.

* * *

Our industry already, to a limited extent, uses both systems in that most lenses are specified in mm for focal length and many ball bearings as well. When conversion was completed we would be better off with an inherently simpler system. The transition period would be difficult, with perhaps the biggest problem resulting from the "English" system base on which our machine tools are built.

It is equally important, however, that electrical standards such as color coding on wire harness, design of electrical connectors, etc. be standardized internationally.

Also, while we're at it, why not establish a decimal time system and angle system. There's nothing very convenient about 24, 60, 90, 360, etc., as multipliers and divisors.

* * *

As a matter of principle, metrication of the United States is desirable in the interest of long range growth of international trade and the eventual simplification of weights and measures, engineering design and manufacturing.

For our particular industry, the cost of conversion will be high, requiring duplicate manufacturing and stocking of repair and replacement parts over a period of time corresponding to the typical ten year maximum service life of a road vehicle or aircraft.

Metrication should be done on a compulsory, but time phased basis for each industrial category to prevent non-volunteers from gaining an unfair competitive advantage, and to spread the economic impact over the economy and through time.

Tax relief should be provided in the form of accelerated write-off of tools and equipment replaced by metrication and through Federal subsidy to help cover increases in state and local taxes caused by larger inventories required during the period of conversion.

* * *

The question of metric vs. English is of minor importance as compared to the effect of international (or national) standardization of dimensions. Whether the basis of such standards is English or Metric is unimportant as long as the dimensions are well chosen and universally accepted.

Examples: Color slides—we call them 2 x 2″ slides. France calls them 5 x 5 cm diapositifs. The important point is not what they are called but that they interchange perfectly. Ditto camera film, ball bearings, motor frame sizes, 19″ relay racks, radio tube pin configurations, etc. Few people know and fewer people care how the dimensions were derived—only that things fit.

* * *

Recognizing the preference of our customers, the scientific community here and abroad, specifications for our instruments are stated in metric units as well as inches. Further it has been traditional in the U.S. optical industry to design and manufacture in metric units.

* * *

Most of our products are now manufactured in the Metric System. Packaging of liquids and most ointments is still done in our customary system (pints, gallons, ounces, pounds, etc.) It will take a great educational effort to convert the public to metric.

The length and circumference of our principal product, cigarettes, are measured in millimeters. All of our engineering standards, machinery, equipment, plant, etc., (with minute exceptions) use the U.S. system of weights and measures.

* * *

We do not believe conversion to the metric system over an extended period of time would be very costly. However converting in a period of five years or less could be unacceptably costly.

* * *

3. SMALL PRESENT NONUSER COMPANIES

a. Any changes in the manufacturing housing industry depend primarily on, and must be coordinated with, lumber standards. All methods and design are based on the English system. A changeover means not only changes of construction methods to conform with metrication, it also entails adaptive changes of design for parts of houses and whole houses. Therefore, the house building (including manufacturing) industry must change with the lumber industry.

Other industries ancillary to house manufacturing are not as critical to the design and manufacture of housing. Adaptive changes of plumbing, heating, electrical, housing fittings and accessories can be made almost independently of house design and with relatively easy changes of methods.

b. Behind the answers to the questions in this part of the study is the idea that everyone will be relieved and benefit when metrication becomes universal, but that the transition period is going to be somewhat painful and costly. Also is the conviction that the sooner the change can be worked out the less painful it will be eventually. Thus, the decision is between long range gain against short range problems.

* * *

1. We are strongly opposed to any partial or voluntary change to the metric system.
2. We are strongly in favor of a complete nationwide mandatory conversion to the metric system which would be based on national legislation.
3. We are absolutely convinced that any voluntary or partial change to the metric system would result in absolute chaos in the manufacturing industry.

* * *

We feel strongly that a change to the metric system should be monitored to minimize the chaotic interim period.

It is not possible to answer the question of converting to metric from linear system of measurement on the form we received.

While I believe that there would be a distinct advantage in converting from linear as far as engineers, draftsmen and shop men are concerned there are mechanical problems which can be quite serious.

Having had considerable experience with the metric system I am familiar with its advantages and disadvantages.

Our present system of measurements is to say the least pretty poor as is our practice of dimensioning drawings in both fractional and decimal dimensions.

Few mechanics, draftsmen or engineers can convert linear dimensions to decimal without use of a conversion chart where drawings are dimensioned in units under sixteenths.

But the real problem comes in converting machine tools built to work to linear measurements. I spent hours during the last world war trying to work out a system of gearing that would enable us to cut metric threads on American lathes and found that there was no possible way of accomplishing it.

This means that the lead screws and the change gears in practically all American lathes would have to be replaced. Some milling machines could come close enough for most work by changing the dials on the feed screws but machines such as jig borers would require extensive changes.

We could redimension our drawings so that both systems could be used, however the problem of fastenings presents a real problem.

While practically all European countries use the metric system each has set up its own thread system. There are at least seven different thread systems and screw sizes running from 2 to 25 mm by one mm increase and the worst of it is that several of them are so close to American sizes that a metric nut will in many instances go on an American screw about half way by hand.

The problem of carrying both metric and U.S. sizes of fastenings and keeping them separated would present something of a problem. We have problems now in the matter as we use both coarse and fine thread bolts in our product and we quite frequently find fine thread nuts in a package of coarse thread.

If we changed to metric we would still have to carry U.S. size bolts and machine screws to take care of repairs for machines in the field. We frequently have machines ten or more years old sent back to us for reconditioning.

This would mean carrying a considerably greater inventory and unless all other countries change to the international system of screw threads would accomplish little as far as making for interchangeability of fastenings.

* * *

We are a small job electroplating firm; we do not manufacture any products of our own. The metric system would not affect us in any way Good or Bad.

1. As our standard products are expected to have long life with minor modifications for improvements and some deviations for special applications, changing of dimensions on most of the shop and installation drawings would be required with very little advantage for domestic use.

2. Changes in other standard products such as the sheet metals and fasteners could cause the following problems:

   1. More waste or higher cost for special sizes
   2. Tooling changes
   3. Change in standard sizes to conform to other industry changes.

3. As our catalogues contain many dimensions, they would have to be printed with both systems for a few years at least. We could, however, use this to some advantage now as an aid to our foreign customers.

4. We have noticed some increased problems with unit conversion as our exports increase. Therefore, we can begin to see the long term advantages of starting a coordinated national program for increased metric usage.

* * *

The metric system would cause considerable problems in that our Drafting Department & Fabrication Department would have to completely change. It is felt that this would directly affect our sales.

* * *

We do not now have a strong company attitude on metrication. Individual attitudes would vary from person to person and, therefore, not be unanimous.

In general, I believe the following statements would be supported by most of our management and owners:

1. Sales and Engineering recognizes the value of a single measurement system when building for a world market.
2. Engineering recognizes the value of the metric system in simplicity due to being in units of ten (decimal).
3. The cost of metrication during the period of years in which a dual system is in effect would be a substantial increase in our cost of production.
4. If metrication is mandatory, the cost effect would be the same for our domestic competitors and, therefore, should be no competitive handicap.
5. Since 64 percent of our cost of production is in purchased parts and raw material, a voluntary system resulting in only partial industrial metrication would be chaotic in perpetuating the dual system to infinity.
6. The ultimate goal of total metrication for our country and the world, when reached, would be beneficial and advantageous to us.

In the interests of worldwide standardization, metric usage should be promoted in line with each industry's ability to absorb any adverse economic impact resulting from the changeover.

Metrication by legislation will result in hardship in many fields. A coordinated national program with voluntary participation for a number of years will eliminate many hardship cases.

* * *

We are a supplier of small metal stampings and assemblies and usually operate under customers prints. We have had dual dimensioned prints which have not presented a problem and could work either system.

We believe one system for international trade would be preferable so we may have to change to the metric system eventually.

* * *

The big problem that I see with metrication of U.S. Standards is, what is the standard? I have been affiliated with several European concerns for the past several years, and have endeavored to get engineering manuals of their standards. This is possible on threads, gears, etc. Any other items, such as steel thickness and diameters, cylinder diameters, etc., is a standard within a certain country, but not a standard in another country.

For example: one of our licensees in England had a heated discussion with the Germans on the sale of one of our products concerning metrication of the cylinder used as a driving force. The Germans argued that unless it was a metric standard, they would refuse to buy it. After a great deal of checking, our English representative discovered there were no metric standards even in Germany on cylinders, but rather an English standard converted to metrics. Herein lies the big problem of converting machine tools, components, etc., to metric standards.

Presently, all of our literature shows both English and metric dimensions. The metric dimensions, however, are conversions to metric and not metric standards.

I personally feel it will be a tremendous problem to convert all countries to a standard acceptable in all countries; let alone standards acceptable within the U.S.

* * *

4. LARGE PRESENT NONUSER COMPANIES

All of our products—cranes, ships, ice machines—require an insignificant amount of finished product specification, for the customer, in terms of a standard measurement system, as compared with internal communications—design to manufacture.

We can easily convert finished product specifications to metric when necessary for export quotations and sales.

Material and components purchased might be more of a problem if not specified in U.S. Standard.

We have over 60,000 drawings of parts and assemblies we make for our machinery. These include parts we supply as repair parts even for machines and ships sold 40 years ago. Since in the course of several years we may need to use a substantial percentage of these drawings (50% estimated) we would be required to convert each and every dimension from U.S. to Metric on every drawing to be used in such production if we had converted our shop measuring equipment and machine tools (and people) to Metric. This would be a tremendous amount of drawing room work and cost with zero benefit, and in parts such as gears, splines and threads interchangeability with old parts could not be maintained.

A very costly part of a transition to Metric for us would be converting shop tools and measuring equipment, and if one also adopts Metric component standards (threads, gears, etc.) we would need tools for both systems, thus requiring more tools and space.

Since the vast bulk of our use of measurement is internal, there is *no* inherent or any other advantage of Metric over U.S. to us. To change from U.S. to Metric would be at enormous cost and no gain in any way. It would take many years of confusion to accomplish, and I doubt if we could survive the process.

Further, there is no advantage to us of having suppliers use Metric in their specifications—if anything it would be a disadvantage if we used U.S. system.

* * *

For this industrial classification (aircraft) the changeover to the metric system will be a long drawn out process because of the long life cycle of an airplane model, typically from 10-20 years.

* * *

While we have given this questionnaire very careful thought, it is a fact, as our answers indicate, that we are unable to find any advantages for our products, or for ourselves as manufacturers, in metrication.

As far as our products are concerned, we would not anticipate any increased competition from imports, but neither could we expect to enjoy a larger export market. Our export sales are limited, partly due to the price levels of foreign manufacturers and largely due, in European or European connected countries, to the electrical standards that exist, and which are not directly related to metric standards. Metrication would be of no assistance whatever in overcoming these areas of sales resistance.

With regard to our various engineering and manufacturing processes, here again there would be no advantage for us. On the contrary, the necessity for dual engineering drawings and specifications and the interjection of dual standards for jigs, fixtures, dies, tools, molds and machinery into our manufacturing operations would cause considerable confusion during the transition period. In addition, and more important to us from an economical standpoint, the cost of training personnel, of maintaining dual standards, and of providing dual tooling and equipment in many cases would be extremely high. We have noted your comments about "normal obsolescence of tooling" and "normal design life cycle" but, for instance, on screws and screw machine products which we produce for our own use, our "customary" standard would remain for many years and we could not add the metric without duplicating equipment.

All in all, we see nothing to be gained for us, our products, or our industry in metrication. Since we are then left with nothing but disadvantages, confusion, and expense we feel that any voluntary program on metrication should be confined to those products and industries which are adaptable to it and where advantages to them and to the United States do exist.

* * *

This company has no strong feeling about the use of the metric system. Laboratory work is frequently carried out in metric units, and only in a few cases is it necessary to translate from metric to English units. Product standards and measurements are almost invariably in English units. The general problem of changing measuring instruments and re-training those who use them is the big task, both economically and in relation to quality. Changeover problems could exist for many years in the understanding and communicating of measurements. The goal would appear to be worth the effort, on a world-wide basis. We foresee no economic advantage resulting from the change to the metric system.

* * *

The use of the metric system would not involve the finished products which we manufacture. It would involve the equipment we use for processing, such as scales, meters and temperature control devices.

Also involved would be all the packages used to pack our products. All packages would need to be redesigned and probably changed in size. This, in turn, would require a change in the packaging machinery used to pack the products.

An estimate of the machinery changes required, which incidentally would not be feasible to phase out over several years, would include:

Thermometers – 250 @ $100 ea.	$25,000
Recorders – temperature – 100 @ $500 ea.	50,000
Recorders – pressure – 50 @ $500 ea.	25,000
Temperature controllers – 25 @ $1,000 ea.	25,000
Scales – various types – 50 @ avg. $2,000 ea.	100,000
Meters – 10 @ $4,000 ea.	40,000
Packaging machines – 20 @ $10,000 ea.	200,000
	465,000
Packaging redesign and inventory loss could amount to about 580 design changes @ $500 ea.	290,000
Inventory loss in "phase out" estimated at 20% of inventory of $265,000...	53,000
	343,000

Estimated Cost of Change-over:	
Equipment	465,000
Containers	343,000
Total	808,000

an $800,000 investment by a company our size with a net worth of about $5 million represents in excess of 16% increase in investment for no tangible benefit.

* * *

The sooner the United States converts from the idiotic English system of weights and measures to the metric system, the better!

* * *

In general, we see no benefits to the overall operations in United States, industry and otherwise, by going metric. The cost to industry of replacement of machinery, training of personnel and change of long standing of inch standards could not possibly be compensated by additional foreign trade. Different laws and different languages in foreign countries are much greater barriers to trade and communications than are the different systems of measurement. A U.S. conversion to metric may actually weaken our industrial leadership. It would be at least another "make-work" project.

There is no reason why the world cannot continue with a dual system of measurement. In the office machines, computers and information processing industries there are inch and metric designed equipments and systems operating in the same business establishments throughout the world without significant problems. In these industries, the U.S. has and is setting the measures, the standards, and terminology of importance. In manufacturing, the U.S. is the outstanding success. We need the help of our Government in expanding these successes.

* * *

I am returning your questionnaire, Part A, regarding the Standard Industrial Classification for the U.S. Metric Study. We could make a changeover, but it would take a considerable length of time to retrain our people. Our technicians here feel that this would cause considerable chaos until such time as all people have learned through their lower-grade education the fundamentals of the metric system.

There would be a considerable cost to retrain present personnel and at this time the Home Building Industry should not be asked to absorb any expenses such as this.

However, as we have gone into new products and new ideas we have made use of the metric system. This is particularly true of work we have done in plastics these past couple years. It's going to take a lot of education, but I think it can be done. But just for kicks, do you have a good re-name for such a product as a "2 x 4"?

We import appreciable quantities of raw materials for SIC Product Groups from countries now on the metric system (Japan, Sweden, Taiwan, etc.). Having to deal with suppliers in these countries on *both* our and the metric system has been and is a constant headache and a source of confusion, misunderstanding and errors.

Similarly, we have numerous license agreement with manufacturers in countries which use the metric system (Sweden, Japan, West Germany, Brazil, etc.) and have had numerous problems connected with the transmittal of drawings, specifications and know-how, which would not have existed if we had been on the metric system.

* * *

Since our company serves so many different industries, providing parts and components to their designs and specifications, our progress to metrication would be at the mercy of the varied rates of progress of our customer industries.

With our essentially 100 percent lack of experience in using the metric system, we find it difficult to see all of the benefits which might come from its being instituted.

We have been annoyed with the lack of easy-to-remember decimal relationships between orders of measurement of linear, area, volumetric and energy quantities and the persistant problem of having to deal with binary and decimal divisions of the inch, but it is difficult to estimate the cost of coping with these inconveniences of the English system over what it might have been if we had been born to the metric system.

If the English system had been too burdensome, it might have retarded the U.S. in technical accomplishment as compared to Metric countries, but this has not been the case apparently, at least not up until now.

A generation of engineers, technicians and mechanics who have dealt with the English measurement system throughout their training and well into their careers will be set back considerably by the necessity of forming new mental concepts of distance, volume, mass and energy as related to materials, fuels and energy transforming media.

With their current familiar concepts, memorized formulae which reduce the terms to be dealt with by means of English unit constants, a man can make rapid, on-the-spot estimates about matters concerning his trade. The prospect of Metric Molliere diagrams and steam tables will give a heat engineer some pause.

How "handy" some of the metric units will be with relation to what is being measured is a consideration. It seems to be a long step from a millimeter to a meter, and some objects will be described in fairly unwieldy numbers, which will not aid in forming a mental concept of their size.

* * *

Our comments on metric usage are generally not favorable. Our company's ordnance products are generally made to final metric dimensions but we have converted all of these into inches and we feel that the training needed to reconvert would be extremely expensive.

Since we do not export at the present time we see no advantage to going to the metric system.

In summation, it appears to us that a change to the metric system would have no advantages for us and would be an extremely costly thing to accomplish.

* * *

Our greatest concern with the proposed voluntary transition is the lack of order and direction that may go with it amongst suppliers, manufacturers and users in the process. It probably should be "voluntary," but specific conversion dates may have to be prescribed as "mandatory." This would of course be an argument in favor of completing the metric changeover program as quickly as possible, once it is started.

As a recommendation if metrication is decided upon, various sectors of the economy should be treated on a year-by-year basis. For example, all land measurement might be changed over in year "A" of the program, all commercial legal weights and measures could be changed over in year "B", and perhaps year "C" could see changes in all manufactured parts and pieces. Following a program of this type perhaps the basic economy could be changed over in a 10-year time period.

But we believe that total, 100 percent, change-over would take two generations, or 40 years. Many machines would continue in operation that long, even though they produced "metric" items. These machines would be serviced; parts and set-ups would be converted from metric to English in process procedures. Such machinery should be scrapped on the basis of economics alone.

Also, this long a period is historic in the experience of other countries; the "conceptual" feel for size, volume, weight, apparently takes two generations to be totally converted.

The experience gained in the United Kingdom should be a good guide for our plans.

* * *

Question 21 of the enclosed questionnaire requested opinions on the general subject of Metrication. We believe that there are some limitations in the use of the Metric system, and the use of it does not assure that it is an easier or simpler system. For example, the foot measurement used in the English system can be divided equally by 2, 3, 4 and 6; whereas, the Metric system measurement can only be divided by 2 and 5. Reducing either the English system or the Metric system down to small tolerances for the purpose of making fine measurements can be done to the same degree of accuracy. The decimal inch provides the necessary tool for making precision measurements using the English unit of measurement.

To change to the Metric system would require a re-education of the entire population in the U.S., which would be extremely difficult. In addition, all of our land surveys, highways, railroads and buildings utilize the English system for measurement. To change all of these would be a tremendous task; the value of which would be doubtful.

We recognize the need of having a universal standard for the entire world. Due to high speed transportation and communications, the effect of the rest of the world on our system of measurement becomes increasingly important. However, we do not see any easy solution to this problem and feel it would be a financial burden too great for either the government or private industry to convert to the Metric system.

* * *

This attachment is in answer to your Question No. 21. In your Question No. 19, I have checked Box C (mandatory program) mainly because I don't exactly approve of the manner in which your program seems to be proceeding.

I have some strong feelings on the matter of converting to metric standards. For the good of the United States, I feel we are long overdue.

I have equally strong feelings in the manner of proceeding. In my opinion, it should be a two-step program. The first step should involve fasteners of all types and this should be mandatory based upon legislation. After this (the hardest part of the program) has been fully accomplished, a coordinated national program could more easily finish the job of conversion.

* * *

We could manufacture our present line of products simply by using conversion numbers for present specifications to describe the product as to quality and size.

All our advantage-disadvantage would be weighted to the disadvantage in maintenance and repairs and dual part supply over a long period of changeover (15-30 years).

Similarly, a disadvantage until present generation of workers, supervisors and sales people learned to think in metric units.

* * *

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This publication reports the results of a study to assess the impacts of increasing metric usage--past, present and future--on U.S. manufacturing industry. The study, conducted pursuant to the U.S. Metric Study Act, is based on responses from more than 2,000 manufacturing companies. Information was obtained on: past and present experience with use of the metric system, including advantages and disadvantages thereof, and the views of the firms with regard to future U.S. policy -- whether the country should continue its laissez faire approach to metric usage, or should undertake some sort of national program to encourage more widespread use of metric weights and measures. A separate survey of a smaller number of selected firms obtained detailed information as to estimated cost impact of a national metrication effort.

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